Vol. 53 No. 1 July 1959

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Vol. 53 No. 1 July 1959

Quarterly

The Standard Technical Journal of Fire Protection for More Than Fifty Years

The NFPA is a non-profit technical and educational organization devoted to the reduction of loss of life and property by fire with a total membership of 17,000. The *Quarterly* is one of the publications regularly provided to members. Other membership publications include *Fire News*, *Advance Reports* to the Annual Meeting, a *Year Book*, and many leaflets, pamphlets and posters issued throughout the year on fire prevention and control. Six volumes of the National Fire Codes are available on an annual subscription basis, one volume free and others at reduced membership rates. For full details on available material ask for a free list of "Publications on Fire Prevention and Protection."

NFPA annual dues are $15.00 for Associate Membership of which $6.00 is for subscription to this Journal. National and regional societies or associations may apply for an organization membership for which annual dues are $100; such a membership entitles four individuals to receive the periodical membership publications.

Technical committees of the Association develop means to safeguard life and property through the publication of standards covering all phases of fire prevention and protection. Your membership in the Association affords an opportunity to keep abreast of these developments and, by being a member, you help support this humanitarian activity. Popular educational literature on fire safety is constantly being produced by the NFPA for distribution through its members to the general public.

National Fire Protection Association

International

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Quarterly

of the

NATIONAL FIRE PROTECTION ASSOCIATION

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Articles and accounts of fires appearing in the Quarterly are based on material forwarded to the Association. The Association, as a body, does not assume responsibility for the accuracy of the material printed herein.

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United Press

Thirty-two buildings in the Village of Lanark, Ontario were destroyed after fire spread from this building housing a sash and door factory to destroy two blocks of the business section. The Ontario Fire Marshal's Office lists wood shingle and tar paper roof coverings among the important contributing factors. Originating shortly after noon on June 15, the fire spread quickly through the unsprinklered building of origin and was carried rapidly before 40 to 50 mile-per-hour winds to other congested combustible buildings in a two-block area. The NFPA has become increasingly concerned with a resurgence of wood shingle roofing in North America and is planning an extensive survey as to the extent of this hazard and the conflagration potentials it presents.

Editorials

NFPA Standards A NEW record of performance in the production of NFPA standards was set in our office recently. In the weeks following the close of the annual meeting on June 5, 1959, 61 new standards were published in separate pamphlet form. These standards run to a total of 2580 pages. Many thousands of copies will be mailed out during the year to a wide variety of members and others concerned with various aspects of fire protection and fire prevention throughout the world.

The listing of the titles of these 61 new standards which follows presents a very interesting picture of the current scope and diversity of the work of our technical committees and gives a fairly good idea of the remarkable contributions made by these committees year after year.

Aircraft Breathing Oxygen System Maintenance Operations
Aircraft Electrical System Maintenance Operations
Aircraft Fuel Tank Repair Operations
Aircraft Fueling on the Ground
Aircraft Rescue and Fire Fighting Services for Airports and Heliports
Aircraft Rescue and Fire Fighting Vehicles Utilizing Foam, Test Procedures for
Airport Fixed Fueling Systems
Aluminum Bronze Powder
Aluminum Processing and Finishing
Blower and Exhaust Systems
Building Construction and Materials, Fire Tests of
Building Exits Code
Central Station Protective Signaling Systems
Centrifugal Fire Pumps
Coal Preparation Plants
Combustion Engines and Gas Turbines
Community Dumps
Confectionery Manufacturing Plants
Controlling Fire Emergencies, Management Guide for
Country Grain Elevators
Dip Tanks
Explosives and Blasting Agents, Code for
Fire Department Ladders
Fire Doors and Windows
Fire Hose Couplings, Use of
Flammable Anesthetics, Use of
Flammable Liquids Code
Flammable Liquids on Farms, Storage of
Flour and Feed Mills
Foam Extinguishing Systems
Gas Appliances and Gas Piping, Installation of
Lightning, Code for Protection Against
Liquefied Petroleum Gases
Magnesium, Storage and Handling of
Magnesium Powder or Dust
Motor Craft, Fire Protection for
Motor Freight Terminals
National Electrical Code
Oil Burning Equipment, Installation of
Outside Protection
Plastics Industry, Prevention of Dust Explosions in
Portable Fire Extinguishers
Portable Pumping Units for Fire Department Service
Proprietary Signaling Systems
Pulverized Fuel Systems
Restaurant Cooking Equipment, Ventilation of
Solvent Extraction Plants
Spice Grinding Plants
Spray Finishing
Starch Factories
Sugar and Cocoa, Pulverizing Systems for
Sulfur Dust Explosions, Prevention of
Tank Vehicles for Flammable Liquids
Terminal Grain Elevators
Titanium
Transit Operations
Water Cooling Towers
Wood Flour Manufacturing
Woodworking Plants
Underground Tanks Containing Flammable Liquids, Leakage from
Zirconium

There are presently a total of some 170 technical standards developed by NFPA Committees. Our 1958 edition of the National Fire Codes, published during the fall of 1958, included 169 technical standards. These Codes were published in six volumes totaling 4,824 pages. Occasionally an NFPA member will question the necessity and desirability of our issuing the National Fire Codes annually, but when it is realized that the 1959 National Fire Codes will include more than 2,500 new pages

affecting 61 of the more than 170 standards, it is readily seen that any other procedure would fail to provide complete and up-to-date material. Members and others working with fire codes and standards want to be sure that they have at hand at all times the complete, up-to-date information and the only way they can be certain of this is to have the National Fire Codes produced on an annual basis.

Australian and New Zealand Sprinkler Records

MR. G. GORDON RUSSELL, Chairman of the Board of Wormald Brothers Industries Limited, Sydney, Australia reported on the Australian and New Zealand sprinkler performance records at the 1959 NFPA Annual Meeting. The statistics cover the period 1886 to 1958 and are based on a total of 2,861 fires in properties protected by wet pipe automatic sprinkler systems.

Satisfactory extinguishment or control was achieved in 99.83 percent of the fires! This compares with the U. S. record of 96.2 percent. Unsatisfactory operation, including one caused by enemy action during wartime, occurred in only 5 cases (0.17 percent!). This compares with the U. S. experience showing 3.8 percent unsatisfactory sprinkler performance. Data on the number of sprinklers operating "down under" indicates:

	No. of Fires	Percentage
Fires involving 1 sprinkler	1914	66.90
Fires involving 2 sprinklers or less	2377	83.08
Fires involving 3 sprinklers or less	2538	88.71
Fires involving 4 sprinklers or less	2641	92.31
Fires involving 5 sprinklers or less	2677	93.59
Fires involving 10 sprinklers or less	2785	97.34
Fires involving over 10 sprinklers	76	2.66

Again, these records are somewhat better than in the U. S. (See the April 1955 *Quarterly*, pages 408 to 423.) No loss claim was made on the insurance companies in 46.73 percent of the 2,861 fires!

Mr. Russell credits the greater percentage of fires extinguished by a smaller number of sprinklers to the fact that for over 50 years all sprinkler installations have been connected to the fire brigade and that almost all installations in large areas have been tested weekly. These practices eliminate trouble with structural extensions and occupancy changes and assure that help is available quickly from the trained brigades to keep the number of sprinklers operating to a minimum.

All concerned, please copy.

Informal Report on Los Angeles

Open Stairway School Fire Tests

By Raymond M. Hill

Fire Marshal, Los Angeles Fire Department

Associate Member, Society of Fire Protection Engineers

The Los Angeles School Building Fire Tests are so recent that even as this report is being written two tests are being run. The reason for these tests is to find possible alternate means of solving fire safety problems in schools primarily from the life safety viewpoint. There are four principal participating agencies. One is the Los Angeles Board of Education. It gave us the use of the building to burn and the ground on which it stands. The Educational Facilities Laboratories, Inc., a Ford Foundation affiliate, is a participating agency. It gave $25,000. The California State Fire Marshal's Office is a participant. This office has the primary responsibility for safety in all life hazard occupancies within the State and thus has a vital interest in what we are doing. Lastly, the Los Angeles Fire Department, which has the same responsibility in our city that the State Fire Marshal has throughout the State, is actively participating and is doing the actual test work.

Two different types of tests are being conducted. One is concerned with providing life-safety features in existing buildings and developing recommendations for schools not yet built. Another entirely separate series of tests is being

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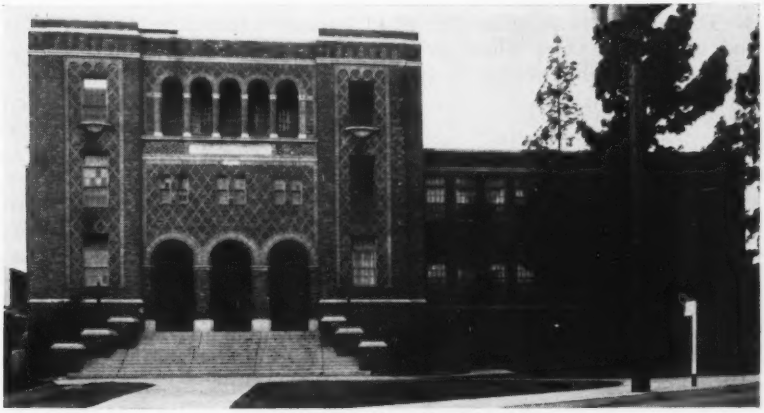
Based on an extemporaneous report by the author presented at the Final General Session of the 63d NFPA Annual Meeting held June 1–5, 1959 in Atlantic City, New Jersey.



The main entrance of the school building used in the Los Angeles open stairway school fire tests. Built in 1925 it will be torn down because of settling.

An exterior view of the three-story, 64 by 95 foot section of the school used for the tests. Exterior walls were brick and the framing concrete.

conducted on fire fighting problems, such as the reactions of firemen while using various types of breathing apparatus. The latter tests are under the command of another chief officer in our department and this report concerns only the life-safety tests.

About the middle of March we had a two-day preliminary discussion to organize and plan the test procedures. This meeting was attended by representatives from the University of California, Underwriters' Laboratories, Inc., Factory Mutual Laboratories, the State Fire Marshal's office, instrument manufacturers, the sprinkler industry and the Los Angeles Fire Department. In addition to the $25,000 grant from the Educational Facilities Laboratories, we received many contributions in materials and time that would be almost impossible to evaluate. A very rough estimate is that a total of about $100,000 in time and materials has been donated. The local members of the National Automatic Sprinkler and Fire Control Association have installed sprinkler equipment in the test building as requested and will take it out when we are through. The American District Telegraph Company has installed smoke detectors, meters for measuring smoke density, and other apparatus. The lumber people have given lumber for building walls and partitions. Minneapolis-Honeywell installed the recording instruments. The various roof vent manufacturers in Los Angeles organized an association to help us. The Insulat-

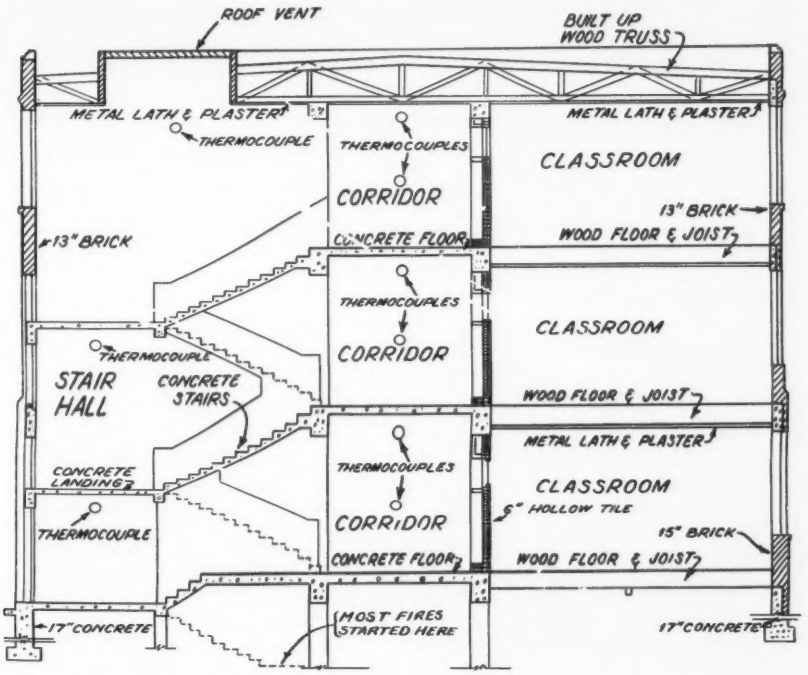
ion Board Institute contributed material. The Gypsum Association did likewise and the local Lathing Institute members installed the necessary walls.

The Test Building and Test Fires

The school building we used is not an old ramshackle building about to fall down. It was erected in 1925 and has brick exterior bearing walls, concrete framing, a wood roof and wood floors in classrooms. Unfortunately it was built on filled ground. In recent years the cost of repairing wall cracks caused by the settling of the structure has been such that the School Board felt it should be destroyed. Buildings have been torn down progressively in the area and new buildings erected. This is the last building to be destroyed. It was used until January of this year for classroom purposes. I was in the first class to enter this school in February 1926 which puts me in the unique position of being one of the few people who legally can attempt to burn down his alma mater.

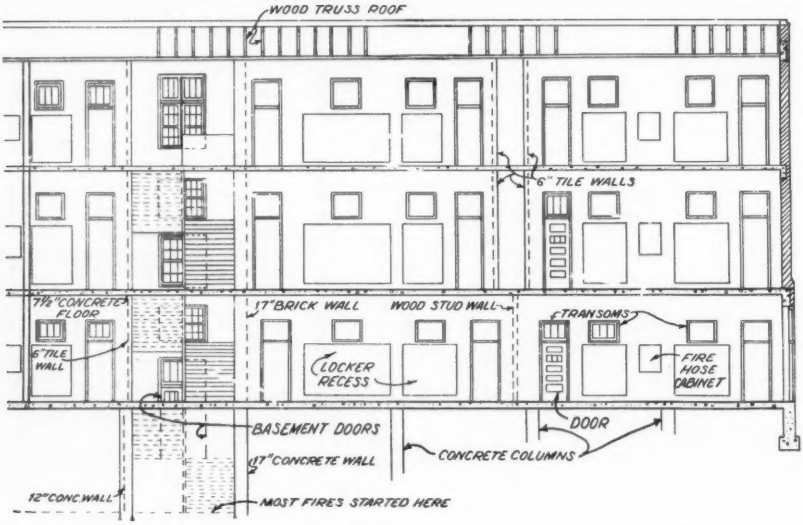
After looking the building over very carefully, we selected a 95-foot-long section of the three-story building for the fire tests and on one end installed partitions to cut off hallways from the rest of the building. For our fire tests, in effect, then, we had a three-story school building, 64 by 95 feet. It had a small basement, two open stairways and an outside fire escape.

Up until May 27, 1959, fifty-nine fire tests had been conducted in this build-

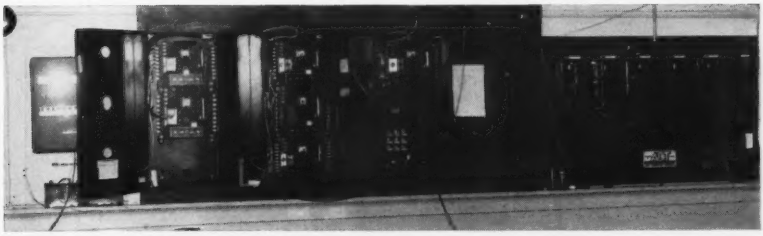


Cross section through the three-story building showing construction details.

View of another side of the building section used for tests. Fires run in the building with the windows open, as shown above, developed untenable smoke conditions more quickly than when they were closed.



Transverse section showing stairshaft in which most fires were started.



The instrument panel contributed by American District Telegraph (ADT) to record operation of smoke density equipment and the rate-of-rise fire detection system installed in some of the test fires.

ing. Five of these were designed to determine the best type of test fire to be used. Slatted wood pallets were ultimately selected as the fuel. Most of the test fires were in 1,400 pounds of stacked pallets. We tried natural gas to give us the heat we wanted and burned some diesel oil to produce the smoke conditions desired. This type of fuel turned out to be desirable only from one point of view since it eliminated the clean-up problem following each test. A wood fire took quite a bit of time to clean up after each test as the charred materials and ash had to be removed. The wood pallets gave us higher temperatures when they were allowed to burn unchecked and provided easily reproducible fires for the number of tests conducted.

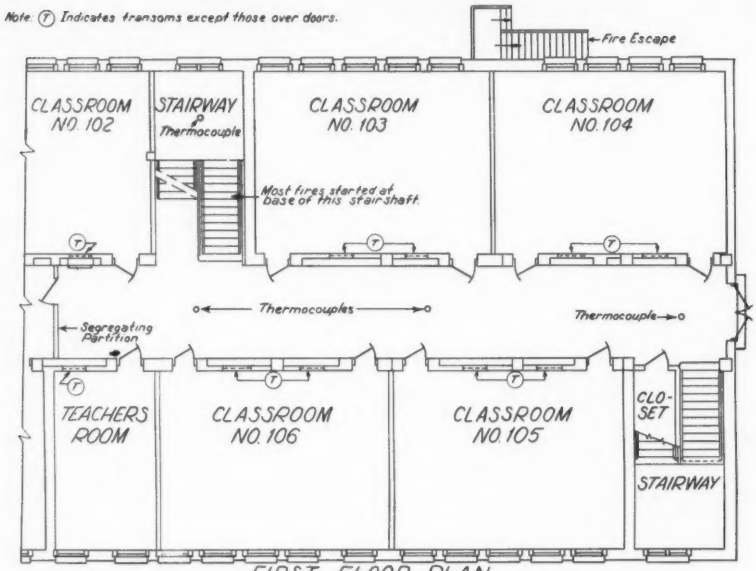
Thirty-eight of the fires so far conducted were the result of burning piles of pallets at the base of the stair shaft in the basement. This meant that we had three full floors above the fire on which we could observe temperature changes and smoke conditions. Eleven of the test fires were from piles of pallets built in classrooms and five were started similarly in the corridors. The other tests have been run since I left the city to give this report.

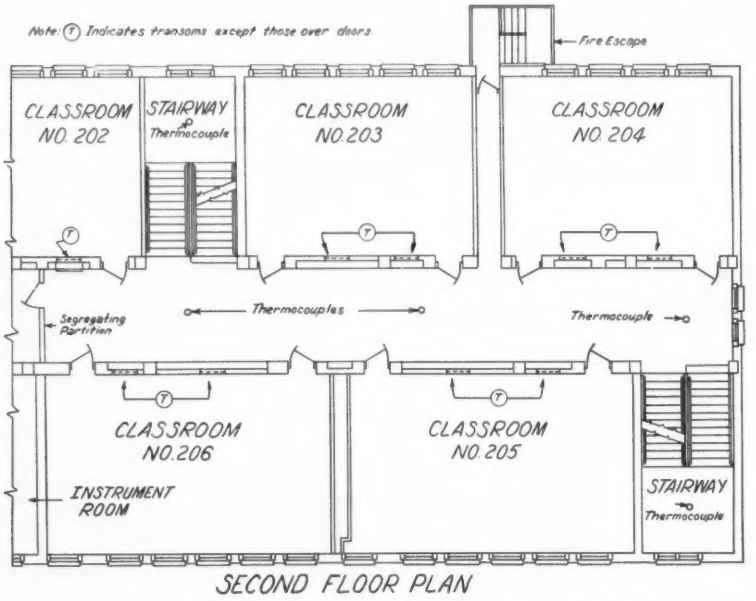
We have already completed a shooting schedule for a school safety film designed to explain the facts about school fire safety for PTA groups, teacher groups, and school administrators. Photographs, both still and motion, are also being taken to supplement the final technical report which will be written when the tests are completed. A definite possibility is the construction of a furnace on Fire Department property to be used, not as a test furnace for commercial testing, but for research on methods of increasing the fire resistance of doors and transom assemblies. It will be designed to test doors up to 7 feet by 7 feet in size.

Setting Up Test Criteria

One basic problem was to determine what would happen in this building if nothing was done to provide protection. Five of the test fires were used to estab-

LAFD personnel checking recorders for thermocouples located in the test area.





Floor plans of first and second floors. Third floor layout similar to second.

Segregating partitions were erected in the corridors (see floor plans at left) with wired glass panels to permit observation of the fire and smoke behavior. Note manometer.

lish this criterion. These tests could not be run first, as would seem logical, since we did not know how much damage such uncontrolled fires might do to the building. We did not want to damage the building extensively, at least until all the other test fires had been completed. Thus, the early tests were under controlled conditions. While this presented a problem since it complicated interpretation of the early data obtained, by running the fires later comparative data could be assembled. Of these five "base" fires, two were started in the basement and three in classrooms.

The building was considered untenable due to smoke when a medium smoke density condition existed. Firemen were used to judge this factor with two observers on each floor. These men, equipped with watches and data sheets, made observations as to when they first observed smoke, when it was light, medium or heavy at the ceiling level and at the five foot level, and when they thought smoke would make the corridors untenable for the average teacher or child. As these observers were professional firemen they could stay in the building longer than could those not accustomed to such conditions but they tried to estimate what the average layman could take. Later on, these observations were related to the instrument readings and then very accurate data were obtainable.

In the basic test fires originating in the basement of this building, smoke made the corridors untenable in from 2 to 3 minutes on the first floor, in about 4 minutes on the second floor, and from 4½ to 6 minutes on the third floor.

This was much faster than we thought it would be. In all my experience in fighting fires I had, of course, learned that if we could not arrive in the first few minutes, at most fires, when we did get there the building would be pretty badly loaded with smoke, but I personally thought untenable smoke conditions would develop much more slowly in a building of this type than these tests indicated.

We picked a temperature of 150°F. as being untenable for the average school occupant. Some experts felt that a higher temperature could be selected, for certainly humans can stand greater heat for short periods. We felt, however, that since the school population consists principally of women teachers and young children, they would find 150°F. awfully hot! In the basic fire tests originating in the basement of the building, heat made the floors untenable in from 5 to 7 minutes on the first floor, from 8 to 11 minutes on the second floor, and from 8 to 11 minutes on the third floor. We reached maximum temperatures on these floors in about 15 to 16 minutes. The maximum temperature obtained at the five foot level on the first floor was 600°F; on the second floor 300°; on the third floor 245°.

A fireman working in a burning building can deal with heat by hugging the floor or getting down on the floor and crawling. Children getting out of school could do this but it would certainly slow down the evacuation and it seems more logical to adopt a criterion for planning that the occupants should walk out in their normal standing positions.

Pallets like these were used for fuel in each test fire. In this case pallets were in the stairshaft at the basement level (stairs in foreground).

In an effort to control fire and smoke conditions in the building, vents were erected over the shafts. The removable panels permitted varying the vent area up to 63 square feet. These vents were judged ineffective.

The basic tests with the fires started in the basement showed that smoke would make the corridors untenable in from 2 to 6 minutes and heat would render conditions impossible within 5 to 11 minutes. The story was not much different when the test fires were started in the classrooms. In the room fires, two of the four transoms between the room and the corridors were left open; the plain glass in the closed transoms usually cracked sometime during the fire. The wood flooring did not burn sufficiently to contribute significant fuel to the test fires. The smoke spread into the corridors in these fires a bit faster than was the case with a freely burning fire at the bottom of the staircase. This meant that untenable conditions were reached somewhat faster. With some doors and windows of the building open, as in summer, untenable conditions were reached more quickly than when these were closed, as in winter. This held true wherever the test fires originated.

Testing Stairshaft Roof Vents

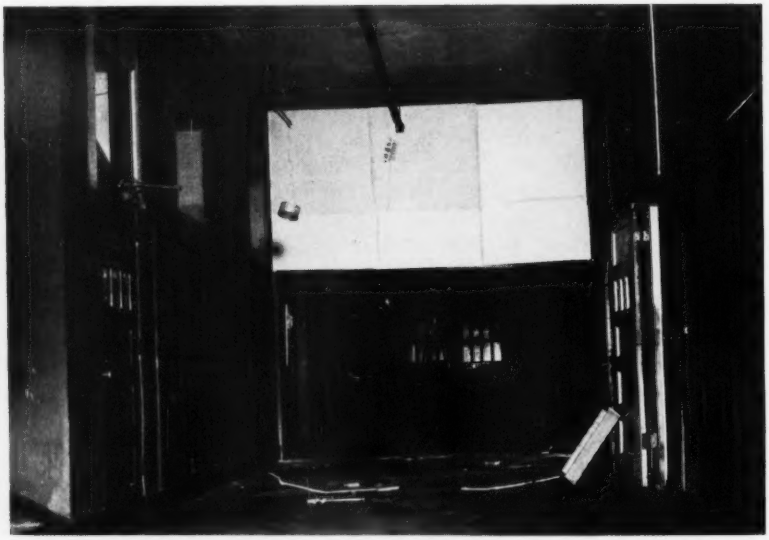
One of the first series of tests was designed to check the effect of putting automatic ventilators at roof level on each stairshaft. The vents were tested two ways. One method, which we called "slow operation," simulated the use of fusible links on the vents at the ceiling level on the top floor. The operation of the vents by this method did practically no good whatsoever in comparison with the basic fire test results. We then tried a "fast operation." In these cases, the vent was manually opened when the automatic detection system installed in the stairshaft over the fire gave an alarm. With either system smoke untenability was reached in from 3 to 7 minutes in the corridors and shafts, just one minute later than the worst condition with no vents at all. More alarming, the untenable heat condition was reached much sooner! Obviously, what was happening was that by placing a draft on the fire, it built up faster. In some cases the heat untena-

bility occurred in less time than the smoke untenability.

The same observers were used to check conditions on each test so that there was no difficulty in having varied results from different persons. A bell system was employed to tell the observers on each floor when the vents were opened so that they could make related time observations on their data sheets. When the vents operated, the men standing at the corridor openings from the stairshafts had to move very rapidly, if not leave the floor, because the sudden arrival of heat and smoke would drive them away. The observers crouched down lower and lower as it got hotter and hotter. One observer thought he would find out if he could rise up and get out faster; he raised his hand above his head to test conditions and scorched the hair off the back of his hand! As they reached the exit doors the natural tendency of observers was to rise up; several had the hair burned off the backs of their necks. As one observer left his floor during these vent tests, he tried to use his data sheets to protect his neck as he raised himself to go through the door with the result that the heat burned off the top of the data sheets!

Draft Curtains and Vents

Since the stairshaft vents did not work so well, we decided to install draft curtains at strategic locations to see if these would help solve the problem. The ceilings were approximately 12 feet high, so we built the draft curtains down a distance of five feet from the ceiling in the corridors and at the stairshaft openings. The curtains did little to improve conditions. The smoke paid little attention to the curtains and spread almost as fast as without the curtains. Smoke untenability occurred within 3 to 7 minutes with the draft



A typical 5-foot-deep draft curtain installed in the first floor corridor. The shiny object hanging at left houses one of the thermocouples, shielding it from sprinkler discharge.

A draft curtain at a stairshaft opening. Smoke largely ignored these curtains and they did not help make the shaft vents work effectively.

curtains installed and heat untenability within 4 to 11 minutes at the various locations checked. This indicates that they made very little difference.

When draft curtains were installed in the center of the corridor midway between the stairways, and the doors at the end of the first floor corridor leading outside were open at the end of the building away from the stairshaft where the fire started, conditions were improved at that end of the building because in this case fresh air was being let in. However, it was too hot in the corridors to assure safe evacuation.

The roof vents did eventually pull smoke out of the building. When this occurred, temperatures at the five foot level were usually 120°F. on the first floor, 290° on the second floor, and 215° on the third floor. You could watch the action through glass observation panels installed in the partition wall erected to separate from the rest of the building the portion being used for the fire test. As the smoke would clear

away and you looked at the temperature recording chart, you knew the building was still untenable for firemen, let alone women and children. The vents in use during this observation were from 42 to 63 square feet in size; under 42 square feet no effective venting resulted.

It was very odd to watch the smoke drift-patterns during the course of the fires. You could stand in the corridors and see the smoke drift up the stairway. Then you would notice the smoke would get more dense. You would turn and look at the other end and see smoke coming down the other stairway! You couldn't predict what it was going to do even with the draft curtains which were supposed to restrict and direct the path of smoke.

The only effective action performed by the draft curtains was when they were installed about midway down the length of the corridors, then, temperatures on the side of the curtain, away from the shaft where the fire was built, remained bearable for a longer period of time than was otherwise the case. Even then it still was too smoky to take for a very long time.

Tests with Sprinklers

We tested both partial sprinkler protection (e.g., coverage of only part of the fire test structure) and simulated complete coverage with sprinklers in the corridors, shafts and locations where the fires were built. The most important observation was that with partial sprinklers (no sprinkler over the fire), the smoke made the entire building untenable before the first sprinkler opened. Even with no sprinklers over the fire, the temperatures were held quite low in the areas where the sprinklers were located (e.g., the corridors) but none of the firemen could stay in these areas because while the temperature readings were relatively low (compared with the temperatures in unsprinklered areas) a moist heat condition existed which was most uncomfortable. When the sprinklers popped, the men left the floor not because they were getting wet, but because the sprinklers drove the hot air down and a lot of steam developed. Visibility was absolutely zero. Bear in mind that this was with *no* sprinkler operating on the seat of the fire.

We then tried partial automatic sprinkler protection along with the roof vents. Different partial sprinkler coverages were used: sprinklers in corridors only, sprinklers in corridors and at the openings to the stairshafts, sprinklers at openings to the stairshafts and in the stairshafts. The worst condition was with sprinklers in the stairshafts (*except* over the fire) because no smoke or heat could be vented under this condition. With temperatures being kept down by the operation of the sprinklers, no venting action occurred and lots of steam developed which likewise was not vented. Actually, as mentioned previously, the smoke made all floors untenable before the first head operated.

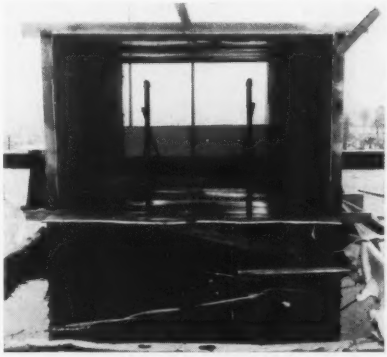
With partial automatic sprinkler protection (none over the fire), open vents and draft curtains, the results were the same. The smoke made all floors untenable before the first head operated.

Only when we had complete automatic sprinkler coverage with a sprinkler working directly on the fire were temperatures and smoke kept at a reasonable level.

In some cases where complete automatic sprinkler protection was simulated, we deliberately "screened" the fire from direct sprinkler discharge. Actually the way the slatted pallets were built, uniform wetting by sprinklers was very difficult at best; the stacking of the pallets covered up the slatted

openings and since the fires were initiated at the bottom of the stack there was no way water could get at the base of the fire. Under these conditions, a great deal of smoke was generated, but these "screened" pallets would be no more difficult for sprinklers to extinguish than a fire in a closed cabinet. However, smoke conditions were tolerable with a slatted-pallet fire when sprinklers were operating directly over the fire itself. On the test fires that the sprinklers could get at they did a very excellent job but when the fires were "screened" so the sprinklers could not get at them by any stretch of the imagination, the smoke was intolerable although the temperatures were held down very well. When the fire was not deliberately "screened" from sprinklers, it was demonstrated that with a good fire drill, the building could be evacuated before the building became untenable.

Where we had a hot fire in a classroom and just a line of sprinklers in the corridor outside, the sprinklers held the fire to the room of origin. While temperatures in the corridor never reached more than 150° F. at the five foot level, untenable smoke conditions were frequently reached throughout the entire building.



The roof "dog house" housing four spray nozzles to induce draft at the vents. This did not help.

Induced Draft at Vents

A suggestion was made to induce a draft through the vent with the thought that such an arrangement would be a possible solution to the problem. We built what we called "the dog house" on the roof over the vent and mounted four high velocity nozzles in it to induce a high velocity air stream through the vent. This only made the fire worse; it was much smokier than ever before with complete untenability on all floors within 1½ to 2 minutes! We really got the fire going with this induced draft arrangement.

Smoke issuing from the "dog house" during one of the tests.

A LAFD fire fighter making observations of smoke conditions in one of the corridors. Note the smoke curling under the draft curtain.

Smoke conditions in the same corridor less than two minutes after the condition shown in the top photo. (Shiny can contains thermocouple.)

Enclosure of Stairshafts

Obviously one solution to the school life-safety problem from fire is complete enclosure of stairshafts as is common practice in other occupancies. We knew this but in our preliminary discussions with school authorities, we agreed that this approach was not a practical solution. A school is somewhat different; many other multi-story buildings have elevator shafts and these are used for the normal travel. No stairway gets as much traffic as in a school building. If the doors are kept in closed position with door self-closers, school administrators tell us they have a high incidence of personal injuries. Kids just do not walk calmly and cautiously between classes — so asking that doors be kept closed is asking quite a bit. Another solution, of course, is to keep the doors open and have a fusible link designed to close the doors automatically in event of a fire condition. However, before these devices operate and the door closes, smoke conditions will be so bad that the structure will be untenable. The tests showed that the doors would close and when they closed temperatures in the balance of the building would be held down but the building still was untenable because of the passage of smoke before the operation of the fusible links.

Corridor Smoke-Barrier Doors

Corridor smoke-barrier doors were installed in the center of the hallways midway between the two stairways. Various arrangements were tried. When the smoke barrier doors were held open and operated with fusible links, the corridors on both sides of the doors became so smoky that none could stand the punishment. When the doors were kept in a closed position with light spring tension, they did keep down the smoke

All but the first four rows of combustible acoustical ceiling tile showing at the top of the photo have been coated with a UL listed fire retardant paint.

After fire exposure the intumescent paint is "puffed-up" and despite direct flame impingement, the fire did not spread on the coated tile.

and heat on the side away from the fire. However, while the fire was building up it would blow the door open and when the fire was vented, a negative pressure occurred which would open the door the other way and suck heat and smoke the opposite way.

Combustible Acoustical Tile

On our very first test fire, when we had about 150 observers present, the corridor ceilings were covered with combustible fiberboard acoustical tile. The tile took fire, flames flashed down the hall and it was necessary to order the doors opened and the fire extinguished by hose streams before too much damage to the test building occurred. All the tile fell, the thermocouples, the ADT detection equipment, and other test apparatus was ruined or damaged. This caused us to get in touch with the Insulation Board Institute to request additional supplies of acoustical ceiling finish materials which the Institute supplied and we installed. This permitted us to run additional fires with "slow-burning"* acoustical material on the corridor ceilings.

With this material on the ceiling, there was no difference as to the amount of smoke or the rise in temperature before the time the corridors became untenable. Smoke made the corridors untenable within 2 to 4 minutes and temperatures within 3 to 9 minutes. During these tests, maximum temperatures at the five foot level were 600°F. on the first floor, 350° on the second, and 280° on the third. This was about what we had on the other fires. After about 10 minutes of fire exposure the ceiling acoustical tile began to burn. It burns with a gas-like flame; it was like watch-

*This rating is based on U. S. Federal Specification SS-A-118b which is a government purchase specification for Prefabricated Acoustical Units.

ing waves washing up on the beach. It begins with a blue flame, then turns yellow, and then races down the hallway. It represents a hazard because of the rapid surface flame spread characteristic. Under the conditions of these particular tests, however, it did not represent too great an additional hazard as by the time the ceiling flashed, corridor temperatures were 670°F. at nose level on the first floor, 355° on the second and 280° on the third floor. Under some other conditions, such as a fire originating in a concealed space above the combustible acoustical tile, the flash fire hazard might be more critical from a life-safety viewpoint.

In another test, we reinstalled the combustible ceiling tile and coated half of its length down the first floor corridor with an intumescent fire retardant paint listed by the Underwriters' Laboratories. In this case, the pile of wood pallets making up the test fire was set halfway up the stairway between the basement and first floor so that flame from the pile would impinge on the coated tile on the corridor ceiling. After 12 minutes of exposure, a blue flame began to "wash" over the tile but after a while this flame subsided. Temperatures were 820°F. on the first floor when this "wash" flame was first observed, 340° on the second, and 240° on the third. Thus temperatures were comparable to those obtained when the untreated tile actually burned in the previous tests.

As indicated, the acoustical tile in the other half of the corridor was not coated with the intumescent paint. A stack of pallets was then placed in the corridor so that, when ignited, flame would impinge on the untreated section of the tile. Ignition resulted and the flame travelled down the corridor and burned over the coated tile. Remember, however, that the intumescent fire retardant

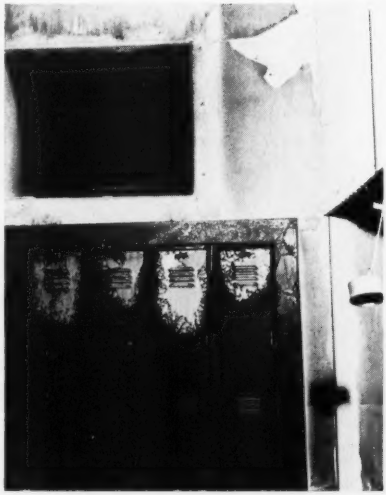
Here a stack of pallets (500 pounds rather than the usual 1400 pounds) has been placed under the uncoated tile. Temperatures reach 1125°F. at the 5-foot level near the test fire.

paint had already been subjected to one fire and had been puffed up by the first fire exposure. In this test, maximum temperatures at nose level were about 1125°F. on the first floor, 285° on the second floor and about 240° on the third.

In these tests with acoustical tile on the ceiling, the corridor was untenable due to smoke in from 2 to 4 minutes in one fire, in from 1 to 2½ minutes in a second and from 1½ to 3 minutes in a third. Untenable temperatures developed at the five-foot level in the corridors in from 4 to 5 minutes and 3 to 9 minutes. The acoustical tile ignited within 10 to 11 minutes.

Modification of Stairshafts

In this particular building, the stairways were so constructed that a person could not stand on the top floor and drop a sack of water on somebody down below. In other words, there was not a free opening in the shaft, as would often be the case in old school buildings. The question was raised whether draft curtains would work differently if the shaft had a free opening such as in old schools. A company was called in to knock out some of the concrete to simulate a free opening. Another series of tests were run with vents, vents with draft curtains at stairshaft openings, vents with draft curtains in the corridors, and other combinations to check for any changes in the smoke and temperature behavior. Oddly enough, smoke made the corridor areas untenable just about as quickly as in the previous tests. We then gave the second stairwell the same treatment to check on how this would influence smoke travel. One test has been run since I left, but from a phone call I have learned that it was one of the worst fires experienced!



The plain glass in the transoms into the classrooms held-up surprisingly well but here one pane has been broken.

To see the effect of a free opening, the stairs were cut open as shown.

Automatic Detection Equipment

Another interesting result from the test data concerns the behavior of the automatic rate-of-rise and smoke detection equipment installed in the test building. A pneumatic rate-of-rise

In the very first test (mentioned on page 22) the acoustical tile took fire and flashed. Fire fighters had to go into action to restrict the damage.

automatic fire detection system installed on the ceiling of the first floor corridor, detected the fire in times between 2 and 5 minutes in 19 out of 25 cases. Some of the variance may be explained by the rates at which the test fires developed. A smoke detector in the stairway of fire origin at first floor level operated to give the alarm in 2 seconds, 21 seconds and the longest was 66 seconds with the fires also originating in the basement. Note that the operation of the rate-of-rise system (no detector over the fire) ran just about a tie with smoke untenability in the building. The smoke detection alarm would have given occupants about 1½ minutes to evacuate before the building became untenable.

When the fire was built in one of the classrooms where there were various conditions such as doors open, one or more transoms open, and the like, the rate-of-rise equipment gave the alarm in 2 minutes within the room and in 2 minutes 40 seconds in the corridor while smoke untenability in the corridor did not come for about 4 minutes.

The Test Procedures and Personnel

I would like to report on how the tests were conducted. First of all, it should be noted that there was a school in session on these same grounds, in different buildings, all the time during these tests. During the week, the tests were run only in the afternoon so as to create a minimum amount of disturbance to the classes that were in session. On Saturdays and Sundays, we could work all day. The personnel requirements were quite high and I am talking strictly from the fire department's stand-

One of the classroom wood panel doors which burned through during a test fire. Panel remaining is wired glass.

point. We had 11 observers from the Fire Prevention Bureau at each fire. We had two on each floor, two on the roof and the rest at selected places in each test. Four men were used as carpenters. We kept them busy all day, every day fixing pallets, closing up the slats in the pallets, putting up and taking down the draft curtains, etc. After the newspaper publicity, we worried that children might think it would be a real good idea to burn the building down before the fire department could finish the tests. It was in a neighborhood subject to vandalism so we had to provide a guard from 7:00 A.M. to 7:00 P.M. and two men from 7:00 P.M. to 7:00 A.M.

Chief J. G. Degenkolb, my assistant, conceived the idea of the tests and talked the School Board into getting financial assistance for conducting the tests. He was in charge of the research section and data collecting and had a captain and four men there every day. Others were out hunting wood for our pallet fires. We didn't have to buy any but it was a chore to find people who had old pallets. Most of those we approached were happy to donate the material but, of course, we had a truck busy hauling. There were a captain and five men there every day to clean up; after every test we had a mess to clean up preparatory to the next test so we also kept a dump truck busy. A standby fire company was on duty during each test in case things got out of control. In round figures, the Los Angeles Fire Department has put in about a thousand man-days on this test program up to the present time. In addition, the American District Telegraph Company had two to four men there every day and they were a great help. Some of the really hot fires damaged a lot of equipment, but they replaced it as needed and were ready to go for each succeeding test.

Informal Conclusions

After reading this informal report, you probably want to know what our conclusions have been to date. First of all, it is clear that "partial protection" (e.g. partial sprinkler coverage, draft curtains at stair openings, vents in the shafts) have so far proved useless.

A complete automatic sprinkler system is a solution. It kept temperatures very low and held down the smoke to a tolerable level; occupants would weep before they got out but it was tolerable. Such a sprinkler system should have a local water flow alarm directly tied into the building evacuation alarm system; administrators should not be given the opportunity to make a mistake in transmitting the alarm.

With a complete automatic fire detection system you should have a couple of minutes of previous warning before smoke would make the building untenable, especially if the fire started in a confined area. When the fire occurred

in an open area (such as in the stairshaft or corridor) it would be touch and go whether you got the alarm first or had untenable smoke conditions. This might be gambling a bit.

We feel, as does our State Fire Marshal, that there should be some other means of getting out of the building than having to enter corridors between two rows of classrooms. Outside stairways are a possible solution to the problem, at least in some locations.

Of course, complete enclosure to each stairshaft is an answer, but I personally do not think it is a practical solution. I do not want to gamble my children's lives on some janitor blocking the doors open. The best solution for new schools: one-story schools with exits from every room to the outside.

Meetings of Board of Directors

Atlantic City, N. J., June 1, 1959

Present

T. Seddon Duke, Chairman
Henry G. Thomas, President
Loren S. Bush, Vice-President
John A. Neale, Past President

Dale K. Auck
Warren J. Baker
W. H. Berry
Charles H. Bunn, Jr.
W. H. Forristall
A. Leslie Ham
Clarence W. Higbee
Paul C. Lamb
William L. Miller
George J. Richardson
Leigh R. Sanford

Percy Bugbee, General Manager

1. The Board voted to send a telegram to Vice-President J. Sharp Queener expressing the best wishes of the Board for his speedy recovery from his present illness.

2. Chairman Duke's report for the Board of Directors for presentation at the opening general session of the annual meeting was approved.

3. Treasurer Hovey T. Freeman's report for presentation at the first general session of the annual meeting was approved. In discussing the financial statement for the previous year which was distributed to Board members at the meeting, the Board voted to refer to the Finance Committee, with power, the matter of investing the $25,000 set aside for investment with the thought that the Finance Committee should consider the appropriateness of some other investment than long-term government bonds.

4. The Board approved a progress report for the 1959 Fall Conference scheduled at the Hotel Fort Des Moines in Des Moines, Iowa, November 11–13, 1959.

5. The Board expressed its satisfaction that Mr. H. E. Humphreys, Jr., Chairman of the Board of the United States Rubber Company, will continue to serve as Chairman of the Sponsors Committee and the Board took notice with pleasure that three additional men have consented to serve on this committee — President Hewitt of Deere and Company, Vice-President Odell of International Harvester Company, and President Power of General Telephone Corporation.

6. Letters of thanks to the Board were read from the new recipients of the NFPA Distinguished Service Awards — Messrs. Bunn, Fetherston and Hudenburg.

7. The Board approved the action of the Industrial Committee in presenting an advisory memorandum entitled "Management Guide for Controlling Fire Emergencies" and authorized the presentation of this to the annual meeting for action.

8. The Board accepted with regret and with sincere appreciation for past services the resignation of member Charles H. Bunn, Jr. as Chairman of the Executive Committee of the Committee on Flammable Liquids and as Chairman of the Sectional Committee on General Storage of Flammable Liquids and as Chairman of the Flammable Liquids Field Service Committee. The Board appointed Mr. Paul Lamb as General Chairman of the Committee on Flammable Liquids. The Board appointed Deputy Chief Raymond Hill of Los

Angeles as Chairman of the Sectional Committee on General Storage of Flammable Liquids. The Board appointed Mr. Elmer Mattocks of the American Petroleum Institute as Chairman of the Flammable Liquids Field Service Committee.

9. The General Manager reported to the Board several matters of current interest including the fact that the Sears-Roebuck Foundation in Chicago was considering the possibility of financial support to NFPA; that the National Safety Council was providing effective cooperation with NFPA in our school fire safety program; that the Fyr-Fyter Company was providing excellent cooperation in the NFPA's membership campaign; and that the Los Angeles Fire Department had expressed appreciation of the services of NFPA Engineer Richard E. Stevens for his work in connection with the school fire tests in that city.

10. Retiring Board members Bunn, Ham and Richardson expressed their gratification at having had the opportunity to serve as members of the Board and their best wishes for continued success of the Association.

11. It was voted to hold the next meeting of the Board at the Parker House in Boston, Mass. on Monday, July 13.

Boston, Mass., July 13, 1959

Present

T. Seddon Duke, Chairman
Henry G. Thomas, President
Loren S. Bush, Vice-President
John A. Neale, Past President
Hovey T. Freeman, Secretary-Treasurer

Dale K. Auck
Warren J. Baker
W. H. Berry
A. Sidney Briggs
Frank J. Fee, Jr.
W. H. Forristall
Paul C. Lamb
Jerome Lederer
Elmer O. Mattocks
Carroll E. Shaw
E. C. Wood

Percy Bugbee, General Manager; Robert S. Moulton, Technical Secretary; Horatio Bond, Chief Engineer; Charles S. Morgan, Assistant General Manager; George H. Tryon, Assistant Technical Secretary.

Business Transacted

1. The following officers of the Corporation were elected: President—Henry G. Thomas; Vice-President—Loren S. Bush; Vice-President—J. Sharp Queener; Secretary-Treasurer — Hovey T. Freeman.

2. Messrs. Elmer Mattocks and Carroll E. Shaw were selected to complete the Nominating Committee for 1960.

3. Plans reported by General Manager Bugbee were approved for the following future annual meetings: Queen Elizabeth Hotel, Montreal, May 16-20, 1960; Detroit, May 15-19, 1961; Philadelphia, May 14-18, 1962; San Francisco, May 20-24, 1963; Dallas, May 18-22, 1964.

4. The Program Committee for the 64th annual meeting was approved to consist of the President, the Chairman of the Board of Directors, and the General Manager.

5. The 1959 Fall Conference to be held at the Hotel Fort Des Moines, Des Moines, Iowa, November 11-13 was discussed by General Manager Bugbee and approved. In response to questions as to attendance, the following members of the Board indicated their intention to be present: Warren Baker, T. S. Duke, Henry Thomas, Dale Auck, Frank Fee, Elmer Mattocks and Sidney Briggs.

6. The report of the Treasurer, Hovey T. Freeman, was accepted. Mr. Freeman's report showed the substantial growth of the Association over the period of years from 1940 to 1959.

7. The budget prepared by the staff and submitted to the Finance Committee—Messrs. Freeman, Duke and Thomas, was presented and approved.

8. Mr. Bugbee reported on the Field Service Sponsors Committee indicating the high calibre of sponsors and reported changes in the personnel of the committee.

9. (a) Mr. Moulton's resignation as trustee of the pension plan was accepted and Mr. Charles S. Morgan was elected trustee in his place.

(b) It was voted to amend the eligibility provisons of the NFPA Retirement Plan so as to reduce the maximum age limit of employees from 55 years and 6 months to 50 years and 6 months, applicable only to persons first employed after July 31, 1959, subject to its acceptability to the Internal Revenue Bureau. The reason for this amendment is basically economic because the cost of taking into the plan an employee older than 50 years is so great as to discourage employment of certain otherwise potentially useful mature persons.

10. After extensive discussion, it was voted to refer the plans for group insurance and major medical expense insurance to the Finance Committee with power, the personnel of the committee to be augmented for the purpose of this consideration by the addition of Mr. Warren Baker, Mr. Elmer Mattocks and Mr. Bugbee.

Field Service and Section Reports

11. Field Service and Section reports were presented as follows:

(a) Mr. Moulton presented the report of the Electrical Section indicating the large amount of time required in the preparation of the National Electrical Code and the devoted service rendered by Electrical Field Engineer Stetka and members of the NFPA staff.

(b) Mr. Elmer Mattocks, Chairman of the Flammable Liquids Field Service Committee, reported satisfaction with the service of Mr. Miles Woodworth, Flammable Liquids Engineer, stating that he had been successful in securing support and agreement on the part of the industry, insurance and regulatory groups.

(c) Mr. Bugbee reported on the Gases Field Service Project indicating similar satisfaction with the work of Mr. Clark F. Jones, Gases Field Engineer.

(d) Mr. Warren Baker reported on the Society of Fire Protection Engineers indicating a healthy condition and discussed their plans for the future.

(e) Mr. Morgan reported on the activities of the Fire Marshals Association of North America indicating the change in the name from the Fire Marshals' Section and the close cooperation between this group and general NFPA activities.

12. Mr. Tryon reported on the Handbook of Fire Protection, indicating various factors which had delayed progress on this book, particularly the Chicago school fire and the large number of standards which have been processed in 1959. Mr. Tryon indicated the expectation that the work would go forward at a faster pace in the future.

13. Mr. Bugbee reported on the Sparky program indicating that the previous deficit had been substantially reduced and that Sparky continues as the symbol used in all NFPA fire prevention literature and is being increasingly recognized in the field.

Explosives Code

14.(a) The Explosives Code referred to the Board by action of the Committee on Chemicals and Explosives, Mathew Braidech, Chairman, was officially adopted in the name of the Association. Mr. Braidech's report indicated that of the membership of the committee of 42, 40 had voted affirmatively and two had not voted. Mr. Bugbee presented a comment from Fire Marshal Nordwick of Stockton, Calif., objecting to the pro-

visions of the Code which permitted the use of concrete mixers for the mixing of explosives and suggesting that this matter should be further considered by the committee but without any objection to the present action on adopting the Code.

Mr. Bugbee then presented the resignation of Mr. Mathew Braidech from the chairmanship of the committee on the ground that his responsibilities to his employer required that he discontinue the large contribution of time and effort involved in the work of this committee. This resignation was accepted with expressions of appreciation to Mr. Braidech for the contributions he has made during the period of his chairmanship.

During the discussion Mr. Auck questioned the use of the term "Code" in the title of this document. After discussion by Mr. Baker, Chairman of the Committee on Laws and Ordinances, it was agreed that the next edition of the NFPA Handbook should discuss the differentiation between "Code," "Standard" and "Ordinance."

(b) No action was taken on changes in the National Electrical Code in view of the lack of agreement between National Electrical Code Committee Panel No. 14 and the Flammable Liquids Committee. This leaves the text of the Code in accordance with the vote of the annual meeting which reverted to the 1956 wording for the treatment of the hazardous area around filling station vents.

15. Chairman Roger Wingate of the Committee on Wearing Apparel presented a report of the activities of his committee outlining a controversy that had developed and the objections raised by certain commercial interests. This was discussed and it was voted that the Board express appreciation of Mr. Wingate's efforts and support of the position of the committee.

Technical Advisory Committee Report

16. T. Seddon Duke reported for the Technical Advisory Committee as follows, with action taken as indicated:

The committee appointments proposed for confirmation by the Board were officially approved. Also a supplementary list of committee appointments was approved. It was voted to make a correction to the previously circulated list deleting the name of Mr. Baker as a member of the Sectional Committee on Storage of Forest Products as he is already an ex-officio member of all sectional committees reporting to the General Storage Committee. (The complete committee lists will appear in the 1959 Year Book.)

It was voted to authorize the Technical Advisory Committee to make additional appointments between the Board meeting and the date of publication of the 1959 Year Book, subject to confirmation by the Board at its next meeting and to reappoint all committee members except those who have resigned or have been dropped for the committee year 1959-1960.

It was voted to discharge the Committee on Wetting Agents and to transfer jurisdiction over the Standard on Wetting Agents, NFPA No. 18, to the Committee on Foam. The reason for this action is the lack of current interest in the Standard on Wetting Agents and the undesirability of continuing an inactive committee on the NFPA books.

The Technical Advisory Committee reported that it was planning to consider the differences between the National Electrical Code Committee and the Flammable Liquids Committee and other committees dealing with special hazards with respect to the requirements

for hazardous areas with the hope that recommendations satisfactory to all concerned could be developed to delineate the respective responsibilities of the National Electrical Code Committee and other committees concerned.

It was voted to constitute the Conference Committee on Pallets and the Subcommittee on Storage of Forest Products as sectional committees reporting to the Association through the Committee on General Storage.

Chairman Duke reported on questions pertaining to manufacturers' representation on the Committee on Signaling Systems and Thermostats and the intent of the Technical Advisory Committee to review the entire matter of manufacturers' representation on this committee with a view to making recommendations to the next meeting of the Board. These plans were approved.

17. The Technical Advisory Committee for 1959-1960 was appointed as follows: T. Seddon Duke, Chairman, Warren Baker, A. L. Brown, Hylton R. Brown, E. W. Fowler.

18. The present Committee on Research was discharged with an expression of appreciation to the committee members for their valuable contribution to the Association and a new committee was appointed with the same scope consisting of all of the chairmen of NFPA technical committees, ex-officio, with Chief Engineer Horatio Bond as Chairman. An Executive Committee was appointed as follows, subject to the acceptance of the individuals named: Warren J. Baker, Franklin R. Fetherston, Everett Fowler, Paul Lamb, J. Sharp Queener, Carl Setzer, J. N. Pryce, Henry Thomas, Roger Wingate.

19. Mr. Bond reported on the Committee on Fire Research of the National Academy of Sciences—National Research Council, indicating the character of research projects that they consider, their financial support from government sources and the fact that their activities, largely in the field of pure research, are interesting universities, private research institutes and government laboratories in research on fire subjects.

20. It was voted to hold the next meeting of the Board at the Union League Club, New York, on January 21, 1960.

21. A communication from Fire Marshal W. J. Scott of Ontario was received.

22. Mr. Moulton discussed the NFPA Standard for Fire Prevention and Fire Protection in Trailer Coaches and Trailer Courts referring to recent action of the American Standards Association on this subject. It was unanimously voted to submit present NFPA No. 501 to the American Standards Association for approval as an existing standard with revisions to be handled under the proprietary sponsorship method and to promote the NFPA standard actively.

Gaseous Oxygen Fires and Explosions

By Arthur E. Miller, Director of Research,
Scott Aviation Corporation, Lancaster, New York

It is not my intention to discourage the use of oxygen. The purpose of this paper is to emphasize the need for careful handling, and to encourage proper instruction and supervision of personnel who work with oxygen. This discussion will be limited to gaseous oxygen, because liquid oxygen, while it presents many of the same hazards as gaseous oxygen, presents many specific problems in itself.

Oxygen is, by far, the most important of all gases. Without it in our atmosphere there would be no life on this planet. Compressed oxygen makes possible many processes in industry, in medical therapy, and in high altitude survival.

Thirty-six years ago a prominent member of the compressed gas industry made the observation that oxygen explosions were occurring with what appeared to be distressing frequency despite the fact that in many instances all of the prescribed rules and safety precautions had been observed.[1] Since that time, the frequency of such instances does not appear to have diminished significantly. However, it must be borne in mind that the use of oxygen has increased tremendously in that

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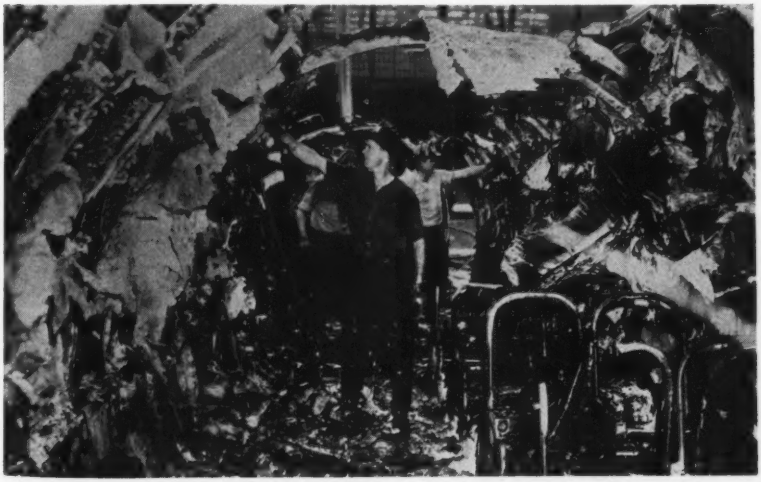
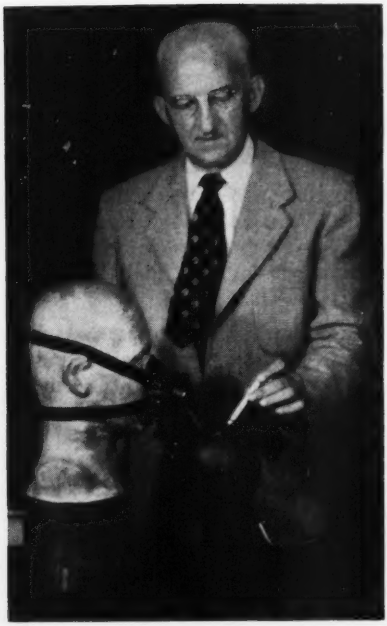
Based on a paper presented by the author at the 63rd NFPA Annual Meeting held at Atlantic City, New Jersey, June 1–5, 1959. Mr. Miller also demonstrated the fire and explosion hazards of oxygen during his presentation.

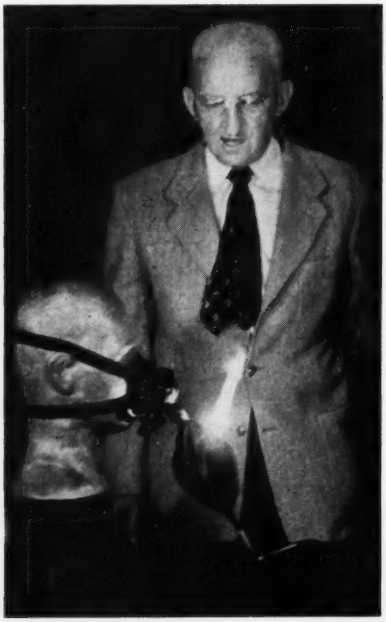


Acme

An internal explosion of an oxygen line during servicing caused severe damage in this DC-4. The explosion originated somewhere between the oxygen cart regulating valve and the first cylinder in the aircraft. The resulting fire originated at approximately the junction of the right wing and fuselage and then spread through the cabin area.



Mr. Miller is about to touch a lighted cigarette to an oxygen mask rebreather bag.



The torch-like flame illustrates the hazard of such an exposure.

same period, so that actually it can be safely said that there has been a great reduction in the number of incidents as related to the usage of oxygen. It is still true, though, that "the history of oxygen has been punctuated by explosions"[2] and that "oxygen burn-outs still occur despite the fact that all precautions are being taken."[3]

Difficulty of Obtaining Information

While there is a great deal of scattered information on the subject in the form of reports in newspapers and technical publications of oxygen fires and explosions, and fragmentary reports of investigations by such agencies as the Bureau of Standards and the Bureau of Mines, much of the work which has been done by independent companies has not been publicly reported.

From personal discussions and correspondence with individuals in the industry it is apparent that many companies have devoted considerable time and expense to investigating oxygen fire and explosion phenomena. However, there is an understandable reluctance on the part of the industry to publicly divulge what it has done and what it has learned. One reason for this reluctance is the fear that some published information might at some future time be used in litigation against either the company which published the information or against one of its associates. Consequently the general attitude in the industry is that what one company discovers through its own efforts and expenses is proprietary information for its own use only.

It is equally difficult to obtain specific information from the military and other

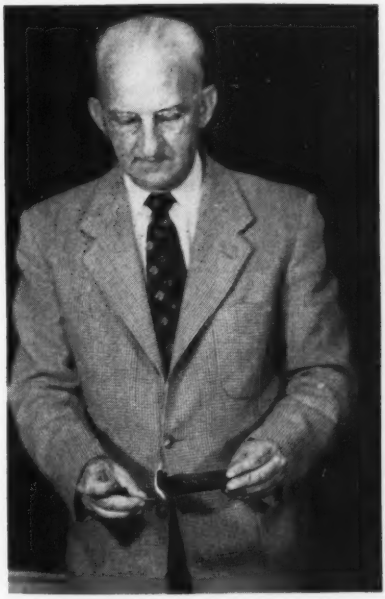
governmental departments. There seem to be no adequate records of oxygen accidents or investigations; most of the case histories and reports are based primarily on the knowledge and memories of individuals.

Another reason for the reluctance to publish information is the fact that the results of investigations are seldom if ever conclusive. In other words, a series of experiments may be conducted with one particular setup or type of apparatus in which a number of specimens of different materials are tested for combustibility. These tests may give the materials a certain grading or order of relative combustibility. However, another investigator working with the same materials but with a slightly different setup may come up with another entirely different grading. The results of any experiment or test can be interpreted only in the light of the equipment which was used for the tests. It cannot be said that because a certain material ignited or exploded in a given experiment, that material will explode under all conditions. Frequently it is impossible to obtain consistent results even with the same material under identical conditions.

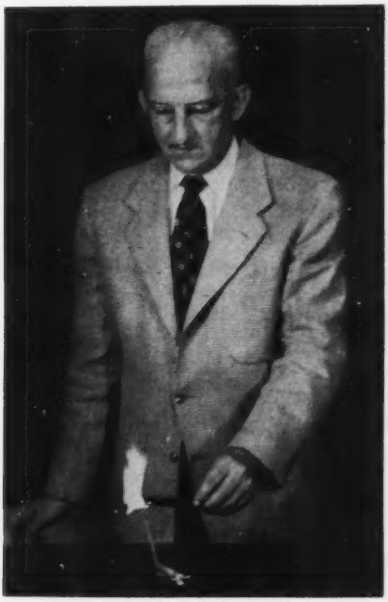
Ignition Requirements

There are, however, certain general parameters which appear to be fairly obvious. One is that an oxygen fire or explosion requires three ingredients: oxygen, a combustible material, and heat.

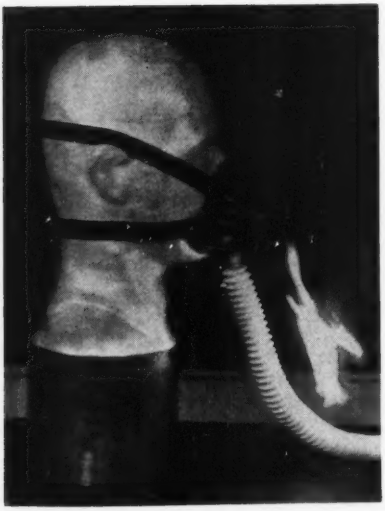
The probability of ignition varies directly with the concentration of oxygen, with the combustibility of the



A flameproofed fabric only chars when a match is used to attempt ignition.



The same flameproofed fabric burns furiously when combustion is assisted by a slight stream of oxygen.



The result of touching a lighted match to the exhalation valve on a demand-type oxygen mask while oxygen is being exhaled through the valve.

material, and with the temperature of either the combustible material or of the oxygen directly in contact with it.

Oxygen itself will not burn, but it supports and tremendously accelerates combustion with any material capable of being consumed by fire. Also, oxygen, being compressible, is capable of initiating fire or explosion by the heat generated in the process of compression. In general, it can be said that the higher the pressure of compressed oxygen, the greater the hazard of spontaneous ignition. But this does not mean that oxygen at low pressure is totally innocuous. It, too, is dangerous; while it is much less likely to cause spontaneous ignition, it can do so under certain conditions.

The term "combustible material" is a very general one denoting not only those materials which are readily combustible in their normal form, but also materials such as iron or steel, which are normally noncombustible but do become combustible at elevated temperatures in the presence of high concentrations of oxygen.

Heat can be either external or internal. External heat could be heat conveyed to the combustible material or to the oxygen in contact with it, either by radiation or by conduction. Internal heat could be generated either within the oxygen circuit or by the oxygen circuit itself. Heat could be generated by sudden compression of the oxygen (known as the "ram," adiabatic heating, or "dieseling" effect). It could be caused also by resonance of oxygen under relatively low pressures impinging into a dead-end cavity; it might be generated by the vibration of a gasket, seal, "O" ring, or other nonmetallic resilient member while surrounded by the high concentration of oxygen. A small-volume, high-velocity leak could cause ignition of material through which it is leaking, by the heat generated through friction.

There is also a possibility that heat caused by friction of a metal-to-metal valve seat or the heat generated by the breaking of a spring or other metal element could cause ignition. Solid particles suspended in a stream could cause ignition either by sparking on impact or by static discharge. Static charges induced by a flow of gas could also cause ignition. Theoretically a metal burr or shred exposed to a high velocity stream of oxygen could become heated to its ignition temperature.

Some of these methods of inducing ignition or explosion can be and have been satisfactorily demonstrated in laboratory experiments which correlate very closely with actual incidents of fire and/or explosion. Other sets of conditions, however, have been experimentally set up, but as far as is known it has been impossible experimentally to

initiate a fire or explosion with these conditions. Yet in many actual incidents the conditions existing at the time of the incident and the nature of the incident itself strongly suggest that one of these methods was the means of initiation of ignition.

Reduction of Oxygen Hazards

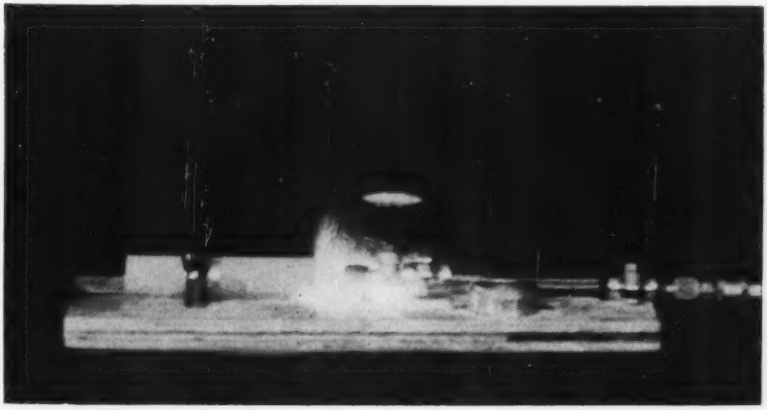
There appear to be only two ways in which the hazards associated with oxygen could be significantly reduced. One would be if there were some means of inducing all oxygen equipment manufacturers, oxygen producers, the military services and other government bureaus to "pool" their knowledge and information and make it available to an independent unbiased group which would evaluate all of the information available and use it either to establish definitely provable facts or as the basis for further research and investigation. The reluctance of industry to publicize its findings, coupled with the interdepartmental rivalry in some of our governmental divisions, make such a program unlikely.

The other method would be if some government agency, such as the Bureau of Standards, would set up a long range program to investigate completely all known incidents of oxygen fires and explosions, and with the knowledge gained, to proceed with a full-scale investigation into all of the possible phenomena associated with oxygen, with the view of making definite recommendations as to the materials and techniques to be used in oxygen equipment, handling, and usage. Such a program is only likely to be undertaken if there is a sufficient demand from the industries concerned with the problem.

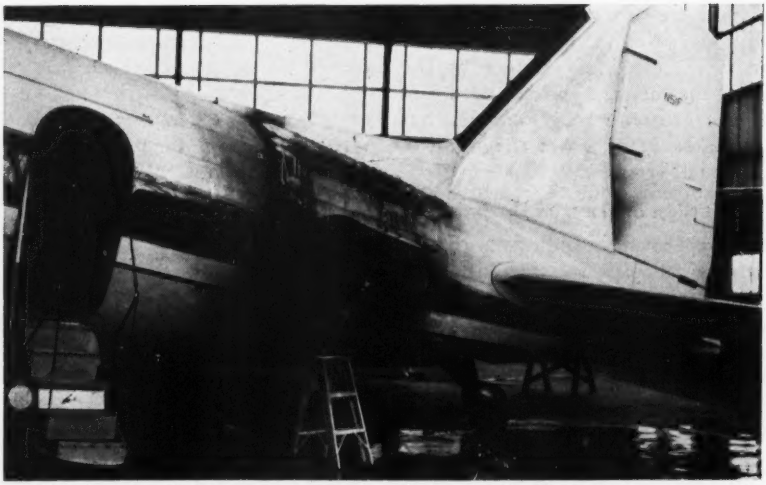
Recommendations

In the meantime, the only recommendations which I can make are that everyone concerned with the production, handling, or use of oxygen bears in mind the three basic factors mentioned in my opening statement; namely, that oxygen fires or explosions require oxygen, plus a combustible material, plus heat.

Oxygen should be used only when no other gas will serve the purpose to be accomplished, such as in oxygen inhalation therapy, oxygen for use at high altitudes, oxy-acetylene welding, and other specific purposes. In such appli-



A piece of hardwood doweling being ignited by a stream of low pressure oxygen (approximately 50 pounds per square inch gauge).



The damage which occurred in a matter of seconds after the oxygen system in this aircraft was turned on and spontaneous ignition occurred in the system.

cations, only oxygen will suffice. Oxygen should never be used as a substitute for compressed air or other gases.

Personnel handling or using oxygen should be trained to distinguish between compressed air, oxygen, and nitrogen, and to use the proper names of these gases. This would eliminate accidents resulting from the practice of using the name "air" for oxygen or nitrogen, thus implying that they are all alike.

Every effort should be made to preclude the contact of oxygen with combustible materials. This is a general recommendation, which must be interpreted with the application of some common sense. There is too great a tendency on the part of some individuals to resort to quibbling over the interpretation of such a recommendation.

We need simply to use some common sense in interpreting this injunction against combining combustible materials and oxygen. A piece of cold steel in high pressure oxygen is perfectly innocuous. In fact, high pressure oxygen is stored in steel cylinders. On the other hand, a piece of red hot steel in a stream of oxygen at low pressure would be extremely combustible.

In the same way, a piece of rubber tubing or a rubber oxygen mask is perfectly harmless in conjunction with low pressure oxygen. That same material could be highly dangerous in high pressure oxygen, especially at elevated temperatures.

The point is that in selecting materials for use with oxygen, we should use the least combustible material which will meet functional requirements. Also, in using the equipment, we must be careful not to allow any

The huge hole burned through the fuselage on the side opposite the door shown in the photo above.

condition to develop which would increase the combustibility of the material. For example, while a rubber oxygen mask is safe with oxygen at low pressure, coating the mask with vaseline or some other organic cream to make it more comfortable on the patient's face would be an act increasing the hazard, because in handling the mask the cream could get on the attendant's hands and be transferred to the high pressure oxygen valve, or to the pressure reducing regulator where such contamination could cause an explosion.

Likewise, the seat material in an oxygen regulator or valve may be perfectly safe when it is new and clean. However, if combustible foreign materials such as dust, lint, or oil should be allowed to get into the valve or regulator, or if with prolonged usage that seating material becomes frayed or abraded, then it becomes much more readily combustible.

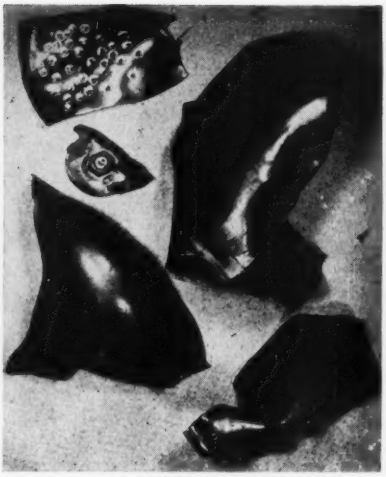
It would seem obvious that since the probability of an oxygen fire or explosion increases directly in proportion to the temperature, every effort would be made to minimize the possibility of the oxygen container or equipment becoming overheated. Again, it is not possible to set a specific number as to what is meant by "overheated." It means keeping oxygen as cool as possible.

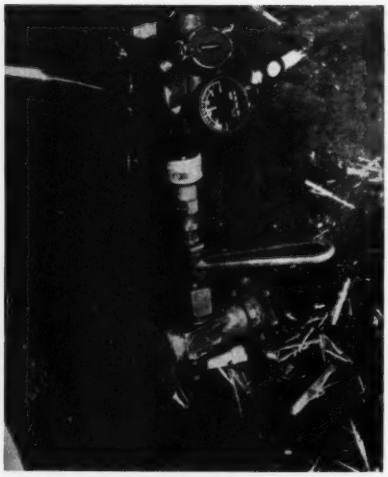
Obviously, if an oxygen cylinder is stored next to a furnace it is going to become hotter than if it were stored elsewhere in the room or building. By the same token, if it is allowed to stand in the hot sunlight it will be hotter than it would be in the shade. Oxygen lines if allowed to pass near the cabin heater in an airplane or near some part of the electrical system or equipment which generates a considerable amount of heat, also can become overheated. Hot oxygen is more likely to cause spontaneous ignition than cool oxygen.

Knowing that heat can be generated by the sudden compression of gas, users of oxygen equipment should bear this in mind and always make it a practice to open the oxygen valve slowly. Again, quibblers may demand a definition of the word "slowly." It is odd that the same people have no difficulty in understanding the difference between walking slowly and walking fast, but when faced with an admonition such as "open valve slowly," they suddenly profess ignorance as to what the word means. To "open slowly" means to open the valve just as slowly as humanly possible. I prefer to open the valve so slowly that the pressure gage on the regulator or on the downstream side of the valve will just creep up the gage scale to the maximum pressure reading. After the needle has stopped moving, thus showing the pressure has equalized on both sides of the valve, then open the valve the rest of the way. This minimizes the possibility of heat being generated by high pressure oxygen suddenly rushing into a dead end space in the valve or in the regulator and recompressing the gas which previously occupied that space. The temperature resulting from such recompression might theoretically be as high as 1700° F., sufficient to ignite even relatively noncombustible materials.

The hazard of ignition by resonant heating may be remote, but it does exist. It has been demonstrated that a low pressure stream (40 to 60 psi of oxygen or air) impinging into a dead end passage drilled into a piece of hardwood can (at a certain combination of relative dimensions and pressures) cause ignition of the hardwood by resonant heating of the gas trapped in the cavity.

Ignition by vibration has been proven to have caused several fires which were investigated in Great Britain. In these cases a leak in a low pressure hose had been patched by applying a piece of





Two employees of an airline were fatally injured by an explosion of a non-ICC approved, small (480 cubic inch capacity), "walkaround" oxygen cylinder (fragments shown at left) during a recharging operation. The cylinder explosion was the direct result of the failure of a seam in the lap-seam, copper brazed vessel. In addition, improper recharging procedures were used including failure to place a reducing valve on the line from the master high pressure master cylinder (shown at right with the connections used). The drill holes shown on one of the fragments were made for metal analysis following the accident.

fabric-reinforced rubber material and binding it over the leak. Vibration of the patch due to leakage was proven to have generated sufficient heat to ignite the patch, and this in turn set fire to the hose and surrounding materials. The pressure in these cases was only about 40 psi. Obviously, care should be exercised in repairing leaks. Whether leakage through an "O" ring or other type of flexible seal could conceivably have similar results has not been established.

Summary

In summary, then, remember and teach personnel, that although oxygen is technically a nonflammable gas it must be handled and treated just as cautiously and with as much respect as an explosive. Properly used, it is indispensable; carelessly or improperly used, it can cause disaster.

References

1. J. K. Mabbs, Report to the Oxygen Regulator Research Committee of the CGMA, November 15, 1923.
2. Fire Station Digest, February-March 1948.
3. J. J. McNernan, CGA Bulletin 1952–79.

NFPA Oxygen References

Standard on Gas Systems for Welding and Cutting (No. 51). Published in National Fire Codes, Volume I and in separate pamphlet form (50¢).

Standard on Nonflammable Medical Gas Systems (No. 565). Published in National Fire Codes, Volume I and in separate pamphlet form (50¢).

Standard for Bulk Oxygen Systems at Consumer Sites (No. 566). Published in National Fire Codes, Volume I and in separate pamphlet form (35¢).

Recommendations for Safeguarding Aircraft Breathing Oxygen System Maintenance Operations. Published in National Fire Codes, Volume VI (1959 Edition) and in separate pamphlet form (50¢).

The British Institution of Fire Engineers

By A. P. L. Sullivan, C.B.E., M.M., M. I. Fire E.

Honorary General Secretary

In the United Kingdom it is generally true that few professional men can practice their professions unless they have passed the examinations of the appropriate learned institution. For example, architects, surveyors, doctors, accountants and so on all have their own institutions through which they must qualify before they are recognized. Accordingly they have achieved high status and a worthwhile position in affairs.

The job of the modern fireman is to an increasing extent bringing him into contact with every field of industrial and domestic life. The profession is being called upon to advise industrialists and town planners in modern development. Advice given at this stage can undoubtedly have considerable influence in the prevention of fire disasters in the future. The scope of this work must depend directly upon the ability, experience and qualifications of the fire officer. It is for this purpose that the Institution of Fire Engineers offers the facility and the stimulus to the fire officer to qualify himself for the job by examination and, through conferences, exhibitions, publications and Branch activities, to exchange ideas, promulgate information and keep up to date with technical development in the profession.

Based on remarks made by the author at the 63rd NFPA Annual Meeting held in Atlantic City, N. J., June 1–5, 1959. Mr. Sullivan was formerly Chief Superintendent, London Fire Brigade, Chief of Staff of the National Fire Service in the U. K. during a part of World War II and Chief of the Aerodrome Fire Service for the U. K. Ministry of Civil Aviation, 1949–1951.

Origin and Purposes

The Institution of Fire Engineers was founded in 1918 by the initiative and farsightedness of a group of fire officers commanding principal fire departments in the United Kingdom. Their intention was to give to the profession a status similar to that which had been enjoyed for many years by other great professions. These officers appreciated that the basic requirements for public recognition of a profession could only be obtained by setting up standards for the professional knowledge and conduct of its members, by stimulation towards research, by the interchange of ideas, and by the publication and communication of information.

The stated purpose of their first resolution was first to raise the standard of the fire service and second to get these

Mr. Sullivan speaking at the 1959 NFPA Annual Meeting.

standards recognized by employing authorities. The standards referred to are purely technical ones. The Institution is not in any sense a trade union and takes no part in conditions of service or matters of management of the fire service. It is also a nonprofit organization.

At present out of 145 fire authorities in the United Kingdom nearly 100 are commanded by officers who are qualified members of the Institution. There are branches of the Institution in Canada, Australia, New Zealand, India and Africa. In most of the British Dominions overseas, the Institution is a recognized standard of qualification for officer appointment in many fire departments. Thus, from a small beginning in 1918, the activities of the Institution are now world-wide and it has become unique in being the only professional Institution for firemanship throughout the world.

Examination Procedures, Membership

The Institution is primarily an examining body and holds a technical examination once a year, on the same day, in February. We usually have about 40 examination centers in all countries in the Commonwealth. The examinations are taken in two parts. A candidate after three years in the fire service may take a Graduateship examination and the following year an Associate Membership examination. The successful examinees are awarded a diploma. We allow certain entries to the Institution without examination, but these must be people who are not professional firemen. A professional fireman can enter only by examination.

Besides a few Honorary Members we have six grades. First, Members, who are elected by the Council from Associate Members, then there are Associate Members, Graduates, Students, Licentiates and Subscribers. The Licentiates are admitted without examination and are usually people connected with the fire service but not in it, such as manufacturers of fire appliances and equipment. The Subscribers are usually bodies, such as Local Authorities and Government Departments. The Students are the younger members of the service who are studying to take our examinations.

The Corporate members of the Institution with voting powers are the Members and Associate Members — in other words people who have passed both examinations.

Examination papers are set and marked by senior officers who are members of the Institution and the examinations are supervised by a university professor and are run to university standards. The Institution is officially recognized by the Government in that it has granted exemption for holders of our diploma to certain central promotion examinations. It also sponsors an annual grant to the Institution to assist us with our work. Many employing authorities throughout the Commonwealth when advertising for fire officers specify that applicants should hold a diploma of the Institution. We hope that one day this will be the universal practice in the Commonwealth.

The Institution is governed by an elected Council of 26 which is split into about six committees for dealing with various matters. One of our principal committees is the Technical Committee whose job is to resolve all technical problems which come our way. They are assisted by 12 Honorary Technical Consultants who are eminent men in universities and elsewhere. The Institution receives technical queries from all over the world and this committee deals with them. We always try to provide an answer.

Publications

The Institution also publishes certain technical books. The latest is a revise of one called "Chemical Fires and Chemicals at Fires."* This book gives an alphabetical list of all chemicals the fireman is likely to meet and it also details, in each case, the properties, precautionary measures, how to cope, first aid measures and the industries in which they are likely to be encountered. In modern industry such a variety of chemicals is used that the fire officer cannot be expected to remember them all and what to do if he meets them. The book is pocket size and we encourage all fire officers to carry one when attending calls. In some fire departments a copy of the book is carried on every fire vehicle.

We have also recently produced three color film strips dealing with fire precautions in hospitals. Each strip contains about 25 frames and lecture notes are available to use with the film strips. They are suitable for fire officers who give lectures to hospital staffs and many hospitals are themselves purchasing the strips for their own use. I refer to these things to give you some idea of the Institution's activities.

This is just a brief version of the Institution and its activities. I hope I have given you food for thought, but I do want to make it clear that we are not contemplating any extension of our activities to the United States.

We who run the Institution quite realize that passing examinations does not make a fireman, but as our examinations are voluntary they do show two things, first that a man has sufficient interest and energy to try to help himself, and second the fact that his studies for the examination must add to his technical knowledge.

Seal of the Institution of Fire Engineers.

*Available from the publishers, Chantry Publications, 63 Neal Street, Shaftesbury Avenue, London W.C. 2, for 10/6 d ($1.52).

Fire-Resistant Hydraulic Fluids

By Richard Davis

Manager of Pydraul Sales, Monsanto Chemical Company

Hydraulics in industry gives us great forces to do work in a most simple, efficient and economic way. From an operating standpoint hydraulics can do many jobs for us which would be impractical and expensive if done strictly by mechanical means, such as screws, linkages, and gears. In industry today, we find hydraulics, for example, used in presses to shape metal parts, in die casting machines, in control mechanisms (such as those used to maintain accurate performance of blast furnaces in steel mills and in boiler and turbine operations) and in hydraulic power lifts (such as used to lift ingots of steel and to manipulate them in and out of furnaces). By the nature of hydraulics, the fluid used is the "backbone" of the system. The most common fluid now used in industrial hydraulic systems is petroleum hydraulic oil. Its low cost and fine lubrication performance make petroleum oil desirable for the majority of hydraulic systems. Petroleum oils also release air and moisture, cool readily and release dirt. Petroleum oil, however, has a serious drawback in certain hydraulic applications — it is extremely flammable when released in atomized or spray form as from a break in a pressurized hydraulic fluid line or the failure of a component part of a hydraulic system.

The Need for Fire-Resistant Fluids

Some industrial hydraulic equipment operates near open flames or furnaces and other high-temperature plant equipment. Consider, for instance, a die casting plant. Die casting operations have pressured hydraulic lines located near potential sources of ignition, such as molten-metal holding furnaces and gas flames. Each die casting machine is subject to vibration and hard use. Hydraulic fluid surges through the lines at average pressures of 1,000 pounds per square inch, often as high as 2,500 pounds per square inch. A weak point in the line may break, spraying fluid amazing distances. The resulting spray-mist of oil is far more flammable than a puddle of the oil itself. If the mist of petroleum oil should strike a hot holding furnace or gas flame, it would immediately burst into a torch, destructive not only to equipment, but potentially disastrous to the people operating the machine and others in the plant area. Indeed, a fine mist of petroleum oil under such conditions can even be, and has been, explosive. In applications such as these, where the benefits of hydraulics are desirable and even necessary, such disastrous situations can be avoided by the use of fire-resistant hydraulic fluids.

Case Histories

Because of these unavoidable fire hazards in many plants, a number of hydraulic fluid fires occur every year. The saddest part of these fires is that most of them could have been prevented. Brief reports on some of the largest hydraulic fluid fires reported in recent years follow.

At a die casting plant in Michigan, a high pressure oil line ruptured near the center of a die casting plant and

Based on an address by the author presented at the 63rd NFPA Annual Meeting, held June 1–5, 1959 in Atlantic City, N. J.

sprayed oil over a hot die casting machine and a gas-fired aluminum melting furnace. Although the fire department was called without delay, the fire was out of control and a loss of $340,000 was sustained.

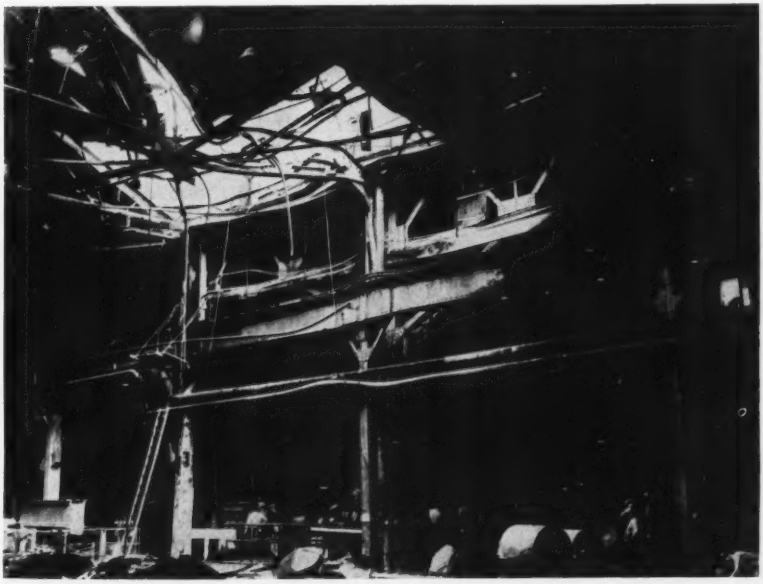
A steel plant reported that a large steel coil snapped, rupturing several high pressure hydraulic lines using petroleum oil in a hazardous area. One man was burned to death instantly, and another is still in the hospital, given little hope for recovery. The final chapter of this tragedy is that the workers protested the lack of safety measures on the management's part with a strike of a few days' duration.

An aluminum foundry in Colorado reported that a flammable hydraulic oil that was released from a broken ⅛-inch hydraulic line sprayed on an electrically heated aluminum melting pot and ignited. The 30,000 square foot wooden building was destroyed to the extent of $450,000.

A steel tinning plant in West Virginia sustained a $925,000 loss because of ignition of a hydraulic fluid.

These "large loss" fires do not include others involving loss of life with only modest fire damage to equipment as has occurred in plants of many types by the accidental release of a spray of flammable hydraulic fluids.

On the brighter side, where fire-resistant hydraulic fluids have been used in potentially hazardous applications, we get reports such as these:



Ignition of flammable hydraulic fluid, released under 750 psi pressure, did severe damage to this plant. The fire made access to the emergency hydraulic shut-off valve impossible, preventing prompt stoppage of the flow of the fluid. The asphalt coated metal roofing in the unsprinklered one-story high building was ignited by the heat of the hydraulic fluid fire and flame spread rapidly along the under surfaces of the roof to extend the damage significantly.

In a die casting plant, an electrical control circuit failed and unloaded the reservoir, blowing the fire-resistant fluid 20 feet into the air over the machine, the operator, the helper, and some of the fluid dropped into an open pot of molten aluminum. The comment of the president of the company was: ". . . instead of a flash fire and serious burns to the workmen, we suffered only to the extent of two fluid-soaked men and 40 gallons of fire-resistant hydraulic fluid."

In another die casting operation: "A very serious accident which could have resulted in physical injury to two of our men was averted by the use of a fire-resistant hydraulic fluid in our die casting machine. On October 25 a hydraulic line hose operating at 1,000 psi on a die casting machine got caught between the two halves of the die, ruptured, and fire-resistant fluid came out of the lines, splashing on the operator, into our aluminum melting furnaces, on adjacent walls and the ceiling as far as 30 feet away. Had flammable oil been used, it would surely have ignited upon falling in the molten aluminum and the fire could have spread over the oil-covered operator as had happened in another plant previously. The danger of fire would have been rendered still worse by the presence of oil vapor in suspension in the air after it erupted from the oil line. The accident has proved to us conclusively the safety value of fire-resistant hydraulic fluid."

And at one steel mill, where fire-resistant hydraulic fluid is used in a blast furnace regulator, a cooling plate around the blow pipe of a furnace burned out, opening the side of the furnace and allowing a jet of flame to be blown out over a group of hydraulic lines some 50 feet up the side of the equipment. Eight of the 64 three-quarter-inch lines ruptured, pouring large amounts of the fire-resistant hydraulic fluid directly into the flame and more than 140 feet beyond. "The fluid was flowing at the rate of 50 gallons per minute," relates one engineer who witnessed the accident. "Altogether about 350 gallons of fire-resistant hydraulic fluid poured into the hottest kind of fire you can imagine. The fluid would burn when it was in the flames, but as soon as it would get away from them it would go out. It won't support combustion the way petroleum oils will."

History of Fire-Resistant Fluids

The history of fire-resistant hydraulic fluids dates back to 1948, when commercial aircraft experienced a number of disasters. Some of these tragedies were partially attributed to flammable hydraulic fluids. The aviation industry searched for an answer — and found it in the form of fire-resistant hydraulic fluids. First used in 1948, these fluids were gratefully accepted and put into use in many of the major airlines throughout the world. There have since been many millions of flight hours with no incident of hydraulic fluid fires. Not one fire has been reported where these fire-resistant fluids have been used! Today, with the coming of commercial jet airline transportation, fire-resistant fluids are specified and standard in all of the jet airliners in this country and many overseas.

As indicated previously, industry also had a need for safety precautions in its hydraulic operations. Seeing the success of the aviation industry in eliminating fluid fires, manufacturers began to demand fire-resistant fluids. New fluids were formulated to meet the requirements of these industrial machines, and were first used in 1950. Since then they have gained wide acceptance, and have definitely proved to be "a means to the end" of industrial hydraulic fires.

Where to Use These Fluids

Because of the many functions performed by hydraulics in industrial plants, it is impossible to merely list the types of equipment with which there may be a fire hazard. Further, some equipment, not possessing a hazard within itself, may be installed near an open furnace with the resulting combination creating a hazard. The best way to evaluate the need for fire-resistant hydraulic fluids is to make formal surveys of your plant operations. A survey sheet, illustrated in reduced size on page 48, can help determine where there may be problems in your plant. Full sized additional copies of this form are available from my company. It makes it convenient to list:

1. The type of machine you have using hydraulic fluid
2. The fluid now used
3. The distance to an ignition source
4. The identity of that ignition source
5. The amount of fluid in the system and the normal and maximum pressures of operation.

This helps define whether or not a spray of hydraulic fluid can be ignited. We generally consider that fluid at 1,000 pounds per square inch can spray a distance of about 40 feet. If there is an ignition source in that range, there is some degree of hazard to the operation.

The form helps you delineate hazards so that the most severe can be handled first. An extreme hazard is defined as a system using petroleum oil, not protected by sprinkler systems, and having a sustained source of ignition within the area that could be reached by a spray or leak of the fluid. A medium hazard is defined as a system using petroleum oil near surfaces of metal or equipment that are heated above the flash point of the oil but below 600°F. A slight hazard is one where an ignition source is only occasionally present, such as maintenance welding, heating salamanders and other temporary hazards.

There is space provided on the form for notes regarding your plan of action. Perhaps moving the machine away from a hazard area will suffice. In other instances, a fire-resistant hydraulic fluid may be desirable.

It is interesting to note how others have used these forms to help reduce hydraulic fluid fire hazards in their plants. After making a survey, officials of one steel mill found (much to their surprise) that they had a hydraulic line running only four inches from the frequent presence of white hot steel. Fire-resistant fluid was installed immediately! Other hazards were less evident, but none the less represented equal dangers and were given immediate and proper attention.

Another firm, after surveying its operations, found over 100 hazard conditions in its plants across the country. There were approximately 25 extreme hazard conditions, most of which could be made safe only by the use of fire-resistant fluid. These plants now operate far more safely than before and with the use of fire-resistant hydraulic fluids, new hydraulic equipment can be brought into the plants and operated near furnaces and in other high temperature areas with complete safety.

Types of Fire-Resistant Fluids

These fluids are "fire-resistant," not "fire-proof." Almost any material can be made to burn. For example, steel, in the form of steel wool, can be made to burn and to support combustion in the presence of oxygen. Finely divided steel powder is not only combustible but explosive; yet steel, per se, is noncombustible when used as a material of construction. By properly choosing

DP 21

HYDRAULIC FLUID SURVEY

PLANT OR WORKS

DEPARTMENT

SURVEY MADE BY | APPROVED BY

DATE SURVEY STARTED | DATE SURVEY COMPLETED

FIRE HAZARD RATING SCALE

MINIMUM	A system not using a petroleum oil as a fluid, but using one of the materials tested and rated "satisfactory" or "acceptable" as a "fire-resistant fluid by Underwriters' Laboratories or Factory Mutual Laboratories, or other qualified agency.
SLIGHT	A system using petroleum oil as the fluid but with no sustained or customarily operated sources of ignition located in the same vicinity.
MEDIUM	A system using petroleum oil as the fluid, with surfaces of metal or equipment in that area heated above the flash point of the oil but below 600°F., and adequately protected with fire control apparatus.
EXTREME	A system using petroleum oil, not protected by automatic fire extinguishing systems, and having sustained sources of ignition within or area that could be reached by a spraying or leakage of oil from the supply or from the return lines. The presence of oil or gas lines in that same vicinity would intensify the hazard even further.

ITEM NO.	2 MACHINE USING HYDRAULIC UNIT(S)	3 FLUID NOW USED	4 DISTANCE TO IGNITION SOURCE, FEET	5 IDENTITY OF IGNITION SOURCE	6 SYSTEM CAPACITY (GALS.)	7 NORMAL SYSTEM OPERATING PRESSURE PSI	8 MAXIMUM DISCHARGE RATING OF PUMP GPM	9 PUMP MFR AND MODEL	10 CONTROL VALVE (S) MFR AND TYPE	11 FIRE HAZARD RATING	12 PLAN OF ACTION FOR REDUCING DEGREE OF HAZARD	13 EXPECTED COMPLETION DATE	14 REMARKS

conditions, fire-resistant fluids can be made to burn. However, these conditions are not encountered in industrial hydraulic applications, and the fluids give maximum protection from fire.

As an example, let us recall the incident where a fire-resistant fluid sprayed through the extremely hot flames of a blast furnace. The engineer was quoted as saying that the fluid burned while it was right in the flames, but self-extinguished as soon as it passed through them. Generally, fire-resistant fluids will burn only where there is already a fire and they do not add to the severity. In other words, once beyond the immediate area of that flame, the fluids will not support combustion, thereby preventing the spread of fire.

There are three basic types of fire-resistant hydraulic fluids:

1. The straight synthetics, which are composed of materials which lubricate and in themselves resist combustion;

2. The water-glycols, which are made of flammable lubricants and about 50 percent water which acts as a snuffer when the fluid is sprayed out against a hot surface or potential source of ignition. The resulting steam blanket prevents ignition of the lubricant;

3. The third type is an emulsion of water-in-oil (about 50 percent water) which obtains its fire resistance in the same manner as the water-glycol fluids.

While petroleum oils of good quality cost about 60 cents per gallon, the water-in-oil emulsions sell for about $1.25 to $1.50 per gallon. They can be used where pressures and temperatures of operation are not excessive. The water-glycols cost about $2.50 per gallon and may be used in slightly more severe operations. The straight synthetics cost $3.00 to $3.50 per gallon, but can be used at any temperature or pressure at which good quality petroleum hydraulic oils can be used. The fluids last almost indefinitely and often leakage fluid is recovered and returned to the system.

Summary

If there is a need for fire-resistant hydraulic fluid in your plant, a survey will help you find it. Once the need for fire-resistant fluid is established, the manufacturer of the hydraulic equipment can help select the fluid best suited for the particular application. Consult with the fluid manufacturer or supplier for helpful information on how to use his fluid in your particular equipment. I urge that you use the fluids in the manner recommended so that they will serve their intended purpose properly, providing both good hydraulic functions and fire safety. Prevent hydraulic fluid fires before they start!

Readers interested in further information on this subject are reminded that in the Proceedings of the 55th NFPA Annual Meeting (1951), pages 44-49, the Association published an article on "Controlling Fire Hazards of Equipment Using Hydraulic Fluids" by George W. Brahmst, Factory Mutual Engineering Division.

Gaps in Fireworks Control

By Helen Augur

Editorial Assistant, *The Sight-Saving Review*

During the first 30 years of this century more people were killed and injured celebrating the nation's independence than in the War of Independence itself. Fireworks killed 4,290 persons and severely injured 120,000, as compared to the Revolutionary War toll of 4,044 dead and 6,000 wounded.

The American Medical Association, shocked by the toll of nearly 500 killed in Fourth of July celebrations in 1903, began keeping count of fireworks accidents. Their statistics were based only on reports sent in by doctors and hospitals, and were far from complete. In 1937 there were 310 eye injuries, in 16 cases involving the loss of one or both eyes. In 1946 there were 45 eye injuries, an improvement of 86 per cent over the tragedies of a decade before. At this point the AMA discontinued the collection of annual figures.

What had happened in that decade was the beginning of state control of fireworks, limiting their use to authorized public displays. By 1946, 18 states had adopted the model law drawn up by the National Fire Protection Association. Today 29 states have the model law, 12 limit fireworks to certain specified types and sizes, and only eight have no statewide control. Moreover, a Federal law prohibits the shipment of fireworks into states where their use by individuals is banned. Decidedly, our national folly of killing, maiming and blinding people, mostly children, on the Glorious Fourth has abated. But the problem is not solved, and the danger of losing some of our recent gains is not over.

Parents, teachers, public health workers and all good citizens need to understand the rather complicated question of safe fireworks. Nobody wants to abolish the beauty and thrill of a pyrotechnic display. Nobody wants an aftermath of death and blindness, nor is this the inevitable price we must pay for firecrackers and rockets.

Provisions of the Law

The model state law is aimed at making fireworks safe. It was prepared by fire marshals in 1937–38, and adopted by the International Association of Chiefs of Police. It is an excellent basic law which works well in any or every state. The term "fireworks" is carefully defined to include dangerous devices, and to exclude harmless ones like paper caps and the toys using them, provided they satisfy the regulations of the Interstate Commerce Commission. As so defined, fireworks must not be sold or used in the state except under permit from the fire marshal or equivalent authority, granted for supervised public displays.

Since the law regulates the use and sale of fireworks but does not abolish them, one clause has unavoidably been a source of trouble:

"Nothing in this act shall be construed to prohibit any resident wholesaler, dealer or jobber to sell at whole-

Reprinted by permission from the Spring 1959 issue of *The Sight-Saving Review*.

sale such fireworks as are not herein prohibited; or the sale of any kind of fireworks provided the same are to be shipped directly out of state. . . ."

This inevitably provided a loophole for the manufacturers and sellers to bootleg fireworks into states where their private use was forbidden. Children had only to look into their comic books or magazines to find the address of a firm offering firecrackers for sale through the mails; trucks laden with forbidden fireworks drove into the model-law states to make quick and quiet sales.

Illinois Campaign

Through the efforts of the Illinois Society for the Prevention of Blindness there had been some regulation of fireworks in that state since 1942, though Illinois did not adopt the model law until 1950. As part of its long educational campaign the Society began collecting its own fireworks statistics when the American Medical Association ceased to do so. In 1951 it recorded 56 eye injuries for Illinois (the AMA had been able to obtain reports of only 45 for the entire nation in 1946); and in 1952 the count was 55. In those two years, under the model law, 13 children lost the sight of an eye or the eye itself.

Meanwhile, Illinois was spearheading a federal drive against the bootlegging of fireworks. Representative Marguerite Stitt Church introduced a bill in the House of Representatives forbidding their transportation into a state where private use or sale was outlawed. Senator Alexander Wiley introduced a similar bill in the upper house, and during 1953 and the early part of 1954 there was a battle royal with the fireworks manufacturers.

Attempts to Weaken Laws

In 1953 Representative Edward T. Miller of Maryland sponsored a bill in Congress which if passed would have had the effect of nullifying the state control laws. Since it was the first of three similar measures presented between 1953 and 1957, and since there may be other attempts of the kind in the future, the Miller bill is of particular interest. It proposed that the Interstate Commerce Commission determine what fireworks were safe for the public to use, and what particular devices complied with these standards, so that they could be identified in commerce. In other words, the bill asked the ICC to undertake a task for which it had no experience, staff, or working facilities. The ICC opposed the measure as "extremely undesirable" in a report to the Senate, whose judiciary committee condemned the bill as perhaps unconstitutional and certainly an unwarranted federal interference in state affairs.

In committee hearings on the Miller bill some of the commercial aspects of the fireworks lobby were revealed. Franklin M. Foote, M.D., executive director of the National Society for the Prevention of Blindness, testified at the hearing of April 22, 1953, about the illicit sale of fireworks in model-law states. He quoted an article in the Hartford *Times* of July 6, 1951, which estimated that the fireworks business in the one small state of Connecticut ran to about seven millions a year. Dr. Foote mentioned the disclosure just made in the same state of a $1,500 bribe given a legislator by a fireworks manufacturer who was fighting the introduction of the model control law into Connecticut. Both the manufacturer and the legislator were convicted in Superior Court, and their appeal was denied by the state Supreme Court. Partly as a result of this scandal, the Connecticut legislature promptly passed the model control law.

Dr. Foote's testimony was unwittingly supported by Representative Miller himself, who testified at the same hearing that he represented some Maryland fireworks manufacterers who would be put out of business if they could not continue to bootleg fireworks into states where their sale was illegal.

The Miller bill failed to find support, and in 1954 the Church-Wiley measure was approved by Congress, and became Public Law 385. It has had on the whole a salutary effect in helping the states to enforce fireworks control. The law makes it a federal offense to transport fireworks into any state in a manner or for a use prohibited by the laws of that state. Offenders are subject to a maximum fine of $1,000 or a year's imprisonment, or both. However, this has not stopped bootlegging, nor attempts by the fireworks interests to kill off the model state laws by a specious federal measure.

Kefauver-Chavez Bills

One of the opponents of the Church-Wiley bill was Senator Estes Kefauver of Tennessee, who introduced a fireworks manufacturer from his state at one of the hearings to argue against the bill. On March 5, 1955, Senators Kefauver and Dennis Chavez introduced a bill identical with the Miller measure, except that it put the responsibility for determining the safety of fireworks on the Federal Trade Commission instead of the ICC. This attempt came to nothing, but on March 14, 1957, it reappeared unchanged as a bill sponsored by Senator Chavez.

A tremendous storm was aroused by this bill, S. 1499. All the forces working for safety were mobilized, and protests poured into Congress. Like the ICC, the Federal Trade Commission did not relish the idea of taking on a task quite outside its prescribed functions. In a letter to Dr. Foote of July 5, 1957, John W. Gwynne, chairman of the FTC, wrote:

"The law presently places upon the Interstate Commerce Commission the duty of prescribing regulations to promote the safe transport of explosives and other dangerous articles. That Commission has promulgated various regulations relating to such articles, including fireworks. Section 836 of Title 18 of the United States Code [Public Law 385] prohibits the transporting of fireworks into any State for use or disposition in violation of that State's law. Thus, such proscription or regulation of fireworks as each State deems desirable in the interest of its citizens is reinforced by a Federal penal sanction, and lawful movement of fireworks in interstate commerce is regulated as to safety by the Interstate Commerce Commission."

Mr. Gwynne added that at the direction of the Commission he had reported to the Senate: "This Commission has no information indicating a need for any additional prohibition or regulation [of fireworks] and therefore does not recommend enactment of S. 1499."

The Chavez bill was never brought to a vote, but the fireworks interests are busy on the state level.

Recent Decisions

On the plea that a model state law bars perfectly harmless devices, fireworks interests have recently made two attempts to kill state laws by having a toy declared harmless.

In August 1957 a Franklin County judge in Pennsylvania declared the state fireworks act of 1939 unconstitutional. Presiding Judge Chauncey M. Depuy of the quarter sessions court rendered a decision in the case of a toy cannon in which acetylene is exploded. He

STATE FIREWORKS CONTROL LAWS
As of January 1959

Sale and Use Restricted to Authorized[1] Public Displays (Model Law)

Alabama	1949	Kentucky	1950	North Carolina	1947
Arizona	1941	Maine	1949	Ohio	1941
Connecticut	1953	Maryland	1941	Oregon	1951
Delaware	1939	Massachusetts	1943	Pennsylvania	1939
Florida	1941	Michigan	1929	Rhode Island	1942
Georgia	1955	amended	1942	Utah	1939
Idaho	1949	Minnesota	1941	Vermont[2]	1946
Illinois	1950	New Hampshire	1943	West Virginia	1939
Indiana	1939	New Jersey	1937	Wisconsin	1947
amended	1947	New Mexico	1949		
Iowa	1937	New York	1940		

Limited to Certain Specified Types and Sizes

Arkansas	Montana	South Dakota
California	Nebraska	Virginia
Colorado	North Dakota	Washington
Kansas	South Carolina	Wyoming

No Statewide Control

Alaska	Missouri	Tennessee[3]
Louisiana	Nevada	Texas
Mississippi	Oklahoma	

[1]Unrestricted sale and use of toy paper caps in accordance with terms of model law permitted in most of these states.

[2]Regulations of the State Fire Marshal, having the force and effect of law.

[3]Fire Marshal Regulations control public displays of pyrotechnics but do not apply to individual use of fireworks.

claimed the toy was harmless, and he was wrong on that score, since the device, the "Big Bang Toy Cannon," had been investigated by the National Fire Protection Association, which considered the calcium carbide mixture in the gun a menace to children — or adults, for that matter. However, the real import of this decision was that it went on to rule that Pennsylvania's model law violated the 14th Amendment of the U. S. Constitution, in that it interfered with the privileges of a citizen. Judge Depuy said the law was too general, prohibiting the sale "of any combustible or explosive composition or combination."

If the decision of this county judge had been upheld by the Superior Court, every model control law in the country would have been in danger. But the Commonwealth appealed, and the decision was reversed in a unanimous opinion on January 21, 1958. The fireworks law was upheld, and Judge C. H. Rhodes, who wrote the opinion, declared that the toy cannon was not harmless, and "children in particular need protection from such devices."

Sparklers are Deadly

In Illinois the fight to break the control law has centered around sparklers. On April 19, 1955, the state Supreme Court rendered a decision in a suit brought by fireworks interest that sparklers were harmless and exempt from the provisions of the model law. The court did not declare the law itself

invalid, but at least the fireworks lobby had made inroads into its effectiveness. The next year the Illinois Society for the Prevention of Blindness found that sparklers accounted for 20 serious accidents and the death of a little girl. From 1950 through the July Fourth celebration of 1956, seven of the 11 deaths due to fireworks were caused by sparklers.

These allegedly harmless devices burn at 1,650 degrees Fahrenheit, leaving a steel core hot enough to sear flesh or set clothing afire.

The Society began a fight in the state legislature, with the fireworks lobby battling every step of the way, and in 1958 got a bill passed banning the sale of sparklers. The fireworks lobby is now trying to get the law repealed, and the fight continues.

Bootlegging Continues

Right across the country there is a pattern of illegal sale of fireworks. Two Oregon boys hitchhiking across the border into Washington, where fireworks are not completely controlled, bought $15.00 worth of firecrackers to be sold at home at modest profit of 100 per cent. Similar reports come from many other states.

The biggest operators, of course, are professional bootleggers. In 1956 the Bergen County, N. J. police were reported to have said that illicit trade in firecrackers, Roman candles, skyrockets, cherry bombs and other dangerous fireworks had reached the highest level since 1937, when the New Jersey control law went into effect.

Salesmen were bringing carloads of fireworks into the state from unrestricted areas and peddling them to children on abandoned lots and even at school street crossings. Openly advertised in comic books and children's magazines, fireworks were being shipped into the state through the mails or by express. In one town weeks before the Fourth, the police had found children setting off bootlegged fireworks, and had confiscated and destroyed quantities of them. Even more dangerous were homemade fireworks, or defective ones sold by small operators.

When the laggard states join their sisters in passing the model control law, and when interested citizens in all states remain alert to the many dangers still inherent in our manner of celebrating our national birthday, it will deserve its rather premature title of "glorious."

New York's BIG Fire Prevention Campaign

By Edward F. Cavanagh, Jr.

Fire Commissioner, City of New York

The major difference between the Fire Department of the City of New York and the most recently organized fire department in this nation is one of size. We both face the same dangers and the same pain. The New York Fire Department budget for the current fiscal year is $108,639,424. It has approximately 2,247 officers, 9,464 firemen and 745 civilians, a total of more than 12,400, the largest number in the Department's history. This article will concentrate on our fire prevention activities.

Actual fire fighting takes only a small part of a fire fighter's working hours. Our entire Department keeps fully occupied during most of its working hours in fire prevention activities. This is done on the basis that most fires are preventable and a perfect job of fire prevention will result in fewer fires and fewer casualties to both civilians and to the fire fighters. For these and other reasons, we regard fire prevention as more important than fire fighting.

Apparatus Field Inspections

Inspection of buildings has always been recognized as a potent factor in preventing fires. When I became Fire Commissioner in February 1954, I decided it was time to supplement the time-honored practice of using separate building inspectors with "apparatus field inspections." This method of checking fire hazards, by which fire

Based on an address by the author at the 63rd NFPA Annual Meeting held June 1–5, 1959 in Atlantic City, N. J.

Night crowds gather to hear Commissioner Cavanagh give a fire prevention lecture on St. Anns Avenue and East 138th Street, an uptown New York shopping district. The apparatus is in radio contact with fire alarm headquarters so it could respond to an emergency as promptly as if in the station.

After 5 children died on November 20, 1958 in Brooklyn while being left unattended, a special educational drive was started to warn parents of this proven danger. These procedures to bring the real lessons on life safety to the people indicate the vigor of the present fire prevention work in New York City.

fighters do inspections operating from their radio-equipped apparatus, started in April 1954 in New York City and the results have been most gratifying. In the remaining nine months of 1954, there were 178,926 of these inspections. The total number of inspections jumped to 1,237,852 in 1958, and, of these, 692,458 were by apparatus field inspection. Each year since 1954, with one exception, there has been a decrease in the number of fires over the previous year. This was a definite reversal in the previous trend which had indicated a rise in fires from approximately 27,000 to 54,000 in a two-decade span.

In apparatus field inspection, the entire city is divided into numbered blocks. Specific blocks are designated for inspection each day, and the program in every local area is supervised by the Department's Fire Prevention Coordinator. This type of inspection does depend on having two-way radio installations in all apparatus to enable the entire crew of officers and men to make the inspections while remaining in service for response to fires. The

The Monarch Underwear Company fire, mentioned by Commissioner Cavanagh, took the lives of 24 employees in this unsprinklered, 5-story brick wood-joisted building on March 19, 1958. Eight of the victims jumped from fourth story windows as they discovered that smoke and heat blocked the stairshaft they were accustomed to use. The others froze at the stair exits and died of suffocation and burns in the fourth story. The fire originated on the third floor in a gas-fired oven used for drying cloth being printed by the silk-screen process.

public is informed that: "This unit is performing apparatus field inspection duty. In addition, it will respond to alarms of fire as received by radio."

Commercial occupancies are completely inspected from roof to cellar. All violations are noted and the responsible persons are notified in writing. Follow-up inspections are made to insure compliance. Activities in private and multiple dwellings are confined to store occupancies, cellars, public hallways and similar areas, excluding apartments.

The entire crew of each unit benefits from these inspections by acquiring new knowledge relating to the premises. The property owner or building occupant benefits, not only by being alerted to fire-breeding conditions but also just because the Fire Department becomes familiar with his property and, if a fire occurs, this assures that it can be confined and extinguished with greater efficiency. On occasions a property owner or business executive will resent the presence of an inspector. In these cases the inspector usually gains his confidence and respect by impressing him with the fact that the object is not to persecute, but to counsel and to be helpful. Accumulations of rubbish, blocked exits and insufficient fire extinguishers are frequently discovered in the course of these inspections, and the public is invariably cooperative when the dangers are made evident.

Special Hazard Inspections

In addition to this type of inspection, chief officers have a schedule of inspections to make. They usually devote themselves to the more hazardous locations within their administrative districts. This assures that not only will these buildings be better maintained from a fire hazard viewpoint, but the inspections give the chief officers the opportunity to plan in advance the fighting of any fire that may develop.

Inspectors assigned to the district offices spend all their working time inspecting buildings. Although members of the uniformed force, they are relieved of all fire-fighting duty.

At the headquarters offices, civilian engineers work at their specialties. There are, for instance, special units for blasting operations and for electrical inspections of fire alarm installations. Where unusual chemical storage problems are encountered, chemical engineers are available to make the inspections and recommendations.

Special Campaigns

All these inspections are supplemented by special inspectional campaigns in high-fire-incidence or high-hazard areas.

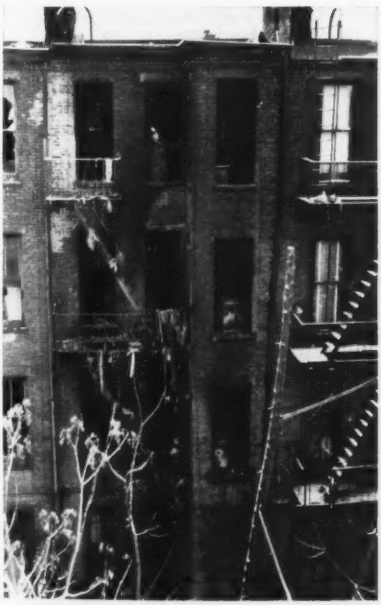
Garment and Millinery Plants

Early in 1958, for instance, mass inspections by selected teams were made in the lower Manhattan loft building area, which is the greatest fire hazard area in New York City. In the course of this special effort, 7,544 occupancy inspections were made in 1,990 buildings. A total of 8,129 combustible violation orders were issued and 2,023 violations were referred to other city departments. Summonses for serious fire safety violations were served on owners of 72 factories.

While this inspection was under way, on March 19, 1958,* we had one of our most tragic fires in the Monarch Underwear plant at 699 Broadway where twenty-four unfortunate workers lost their lives. As a matter of fact, the inspection of these fire traps had been going on steadily for two years. This dreadful fire only emphasized the fact that if the Fire Department were several

*See April 1958 FIRE NEWS, pages 4–5.

This oil stove, being exhibited on a F.D.N.Y. fire truck for educational purposes, was the cause of a fire fatal to 5 persons on February 1, 1958 in Brooklyn, N. Y.



The photo shows the extent of the damage to the multi-story tenement building in which the stove shown above was used. A campaign to rid the city of these stoves has resulted in a sharp reduction in loss of life from this cause.

times its size and if it were to stay on the job continuously for two or more years, it could not possibly clean up all the fire hazards in this particular area. It must also be remembered that there are several other sections in the city where the same sad conditions prevailed.

Accordingly, two things were done immediately. First, we had local legislation enacted tightening the fire laws. Second, and by far the more important, we organized a fire warden system in each of the thousands of garment and millinery plants. This was possible only through the active cooperation of the city's top labor leaders. David Dubinsky, head of the International Ladies Garment Workers Union, which had lost 18 of its members in the Monarch fire, took the initiative in this movement. We have trained all these fire wardens, who now number 6,550, working in as many factories. They are doing a grand job.

Schools

We have always inspected schools and our school authorities have been active in this regard. However, immediately after the dreadful tragedy in a Chicago school,* which took the lives of 91 little children and three nuns, we made a sweeping and unprecedented inspection of all New York City schools. I issued the order on December 2nd, the day following the disaster. Between December 3rd and December 22nd, we inspected 2,044 schools. We closed 36 schools in this intensive drive because of fire hazards. In these inspections, we had the wholehearted cooperation of the heads of our schools, public and private.

Obviously, this is not enough. Another Chicago school fire can be averted only by constant vigilance. Starting

*See January 1959 QUARTERLY, pages 155 to 175 (Reprinted in pamphlet form as Q52–8, 25 cents a copy).

this year, we will have two thorough inspections of all schools annually, one in April and May and another in September and October. The 1959 spring inspection has been completed and we were highly gratified with the results. Besides these spring and fall inspections of the schools, our battalion chiefs make monthly spot checks.

Hospitals and Other Institutions

In January of this year the 36 public and 164 private hospitals in New York City were inspected. We found 153 violations in the public hospitals and 713 violations in the private hospitals. All these violations were corrected.

In March similar inspections were made in nursing homes, asylums and other institutions. Comparatively few violations were found because similar inspections had been made last November.

Some Inspections Resented

Occasionally these inspections are deeply resented. Just a few weeks ago, our officers and inspectors visited a Fifth Avenue department store. We had to close it. Two newsmen were present. The owners or their agents were downright and unnecessarily offensive. They could not put the Fire Department out of the building but they unceremoniously ordered the newsmen to leave, threatening to throw them out if they did not get a move on and then warned them to be careful about what they published. All of this was, of course, duly reported in the press. This shameful treatment of the press burned me up and I could not help exclaiming: "What you need here is a little courtesy and a good public relations man."

Kerosene Stove Problem

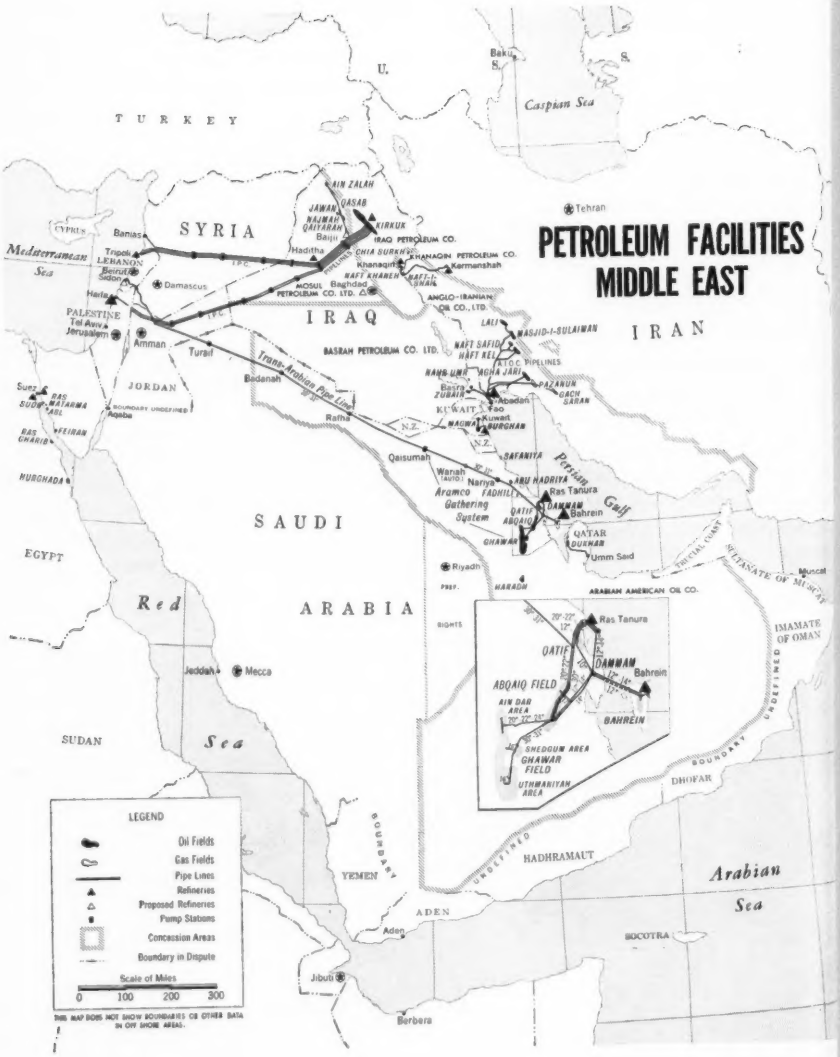
Formerly, it was taken for granted that a score or so would die annually in the City from kerosene oil stove fires. For example, in one year we had 27 of these needless fatalities. These tragic casualties were almost entirely confined to the winter months.

Commissioner Cavanagh lectures a crowd of neighbors on the dangers of portable kerosene heaters and kerosene stoves. This photo, taken on November 13, 1956, was at the corner of Rivington and Suffolk Streets, a heavily populated district of Manhattan.

In the fall of 1954 we began a drive to put an end to these deaths. To achieve results, the people who were using these dangerous kerosene oil stoves and heaters had to be educated. Thus, each time there was a kerosene oil stove fatality, we made a spectacular drive in the immediate neighborhood of the fire. The stove that caused the tragedy was mounted on one of our fire engines and driven throughout the neighborhood. Crowds which gathered were lectured in English and Spanish to warn them against using defective stoves and the hazards of filling them while they were burning. Talks were also given on the proper care, operation and placement of these stoves and these instructions were printed in English and Spanish to help in this educational program.

But I was determined to rid the city of these stoves. Our Mayor, the Honorable Robert F. Wagner, gave us his immediate support. Accordingly, our anti-kerosene stove law was enacted on December 8, 1955. This law made it illegal to have kerosene stoves in any building not a dwelling on and after January 1, 1957; in private dwellings on and after November 1, 1957; in tenements with ten or more apartments, hotels and rooming houses, on and after November 1, 1958, and in multiple dwellings with less than ten apartments on and after November 1 of this year. So you see that in a few months we will have rid New York City of kerosene oil stoves and heaters.

While this law was gradually ridding the city of these dangerous contrivances, we continued the educational campaign with unabated vigor. That we were effective is evident from these figures: in the winter of 1955–1956: six deaths; in the winter of 1956–1957: nine deaths; in the winter of 1957–1958: eighteen deaths, and in the late winter months of 1958: one death. We have had no deaths so far this year from kerosene stoves.


PETROLEUM FACILITIES
MIDDLE EAST
TURKEY
SYRIA
IRAQ
IRAN
SAUDI ARABIA
JORDAN
EGYPT
SUDAN
YEMEN
ADEN
HADHRAMAUT
DHOFAR
Caspian Sea
Mediterranean Sea
Red Sea
Arabian Sea
Persian Gulf
Tehran
Baku
Damascus
Amman
Beirut
Jerusalem
Baghdad
Basra
Kuwait
Riyadh
Jeddah
Mecca
Aden
Bahrein
Qatar
Dubai
Muscat
Ras Tanura
Dammam
Abqaiq
Qatif
Ghawar
Trans-Arabian Pipe Line
Aramco Gathering System
Iraq Petroleum Co.
Basrah Petroleum Co. Ltd.
Mosul Petroleum Co. Ltd.
Anglo-Iranian Oil Co., Ltd.
Arabian American Oil Co.
Abqaiq Field
Ain Dar Area
Bahrein
Shedgum Area
Ghawar Field
Uthmaniyah Area
Trucial Coast
Sultanate of Muscat
Imamate of Oman
Undefined Boundary
Boundary in Dispute
LEGEND
Oil Fields
Gas Fields
Pipe Lines
Refineries
Proposed Refineries
Pump Stations
Concession Areas
Boundary in Dispute
Scale of Miles
0 100 200 300
THIS MAP DOES NOT SHOW BOUNDARIES OR OTHER DATA IN OFF SHORE AREAS.

Protecting Middle Eastern Petroleum Plants

By George F. Prussing
Consulting Fire Protection Engineer
Member, Society of Fire Protection Engineers

Most of the oil exported from the Middle East comes from four countries, Kuwait, Saudi Arabia, Iran and Iraq. In addition, sizable amounts are produced in the Kuwait Neutral Zone and the Shaikhdom of Qatar, and smaller amounts on the Island of Bahrain and in Egypt. The total is very roughly 25 percent of the oil production of the free world. But the oil discovered and not yet produced in these fields is close to two-thirds of the total reserves of petroleum of the free world and therein lies the strategic importance of this area.

Last year in one of the Middle East oil refineries in the Persian Gulf — a very large and modern plant — a job of drumming gasoline for export was in progress. It was a special order for a friendly government and the drums were branded with the symbol of the government and the destination. A huge storage area was filled with drums, in long rows, the drums lying on their sides and piled three high. Narrow aisles led through the piles.

The drumming plant shut down at 4:30 in the afternoon. It was still daylight, when, a few hours later, a local employee saw smoke rising from the center of the drum storage area. He ran to the nearby gate and gave the alarm to the gateman who telephoned it to fire headquarters. Now, in the early days of the Middle East oil business, native workmen were not presumed capable of handling emergencies and hence never touched fire equipment. But this man had been trained in the refinery's fire school. He therefore ran to the "ready-hose" station nearest to the fire, unreeled the hose and actually had put out the fire with his small, high-pressure water hose stream and fog-tip when the fire department apparatus arrived.

Then it was discovered that a spectacular blaze had involved the drum filling house. All of the sample cocks on the filling lines had been opened into the sampling sink and had been set afire. It did not take long to unpressure these fill lines and kill the fire.

Obviously both fires were incendiary; the drum fire was the major attack and the drum house fire was a diversion. Fortunately, they were discovered and put out in that order. Had the drum storage fire gotten out-of-hand it would have been tragic, for drums will burst and scatter in all directions. I recall one in Christchurch, New Zealand, where some of the rocketing drums were said to have gone 600 feet into the air.

Here was a local Arab workman who had been trained in a fire school to do a number of simple things in a given order in case of fire; he called the fire department first and then he did his best with the ready equipment that had been strategically located. In that one fire he justified all that had been spent over the years in making every workman an auxiliary fireman.

While an old story in the United States, this concept of teaching fire protection to the lowest order of workmen

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Based on an address by the author at the 63rd NFPA Annual Meeting held June 1–5, 1959 at Atlantic City, N. J.

in a plant is an American importation into the Middle East, where, in earlier days, all supervisors were British. The British Fire Masters came from the British Fire Service and hence were trained in the municipal rather than the industrial approach to the problem. They organized excellent fire companies, always staffed with British officers, and it was rare indeed to find an Arab except in the ranks. No workman was ever allowed to touch a piece of fire apparatus, except under direct supervision and orders. The change from this system has been gradual but in most locations you will now find extensive use of "ready-hose" stations and hundreds of workmen who have been through schools where they have handled similar apparatus against test fires.

Loss of Production Most Important

The approach to fire protection in any situation depends greatly on the economics of the enterprise. One question that must be asked is whether the possible fire loss will be in goods and structures or in loss of production. An example of a facility in which production was far more important than structures was Kuwait in 1951. You will recall that in that year Iran nationalized its oil business and the Anglo-Iranian Oil Company withdrew its technicians from Abadan under the guns of a British cruiser. Mr. Mossadeqh was going to try to run the company facilities with local labor but, because of an embargo, he never succeeded.

Meanwhile a gap of nearly three quarters of a million barrels a day of crude production had to be filled from other fields and Kuwait was one of the two most ready to pick up the load. Kuwait was then producing about 400,000 barrels a day but its wells were capable of being opened-up to double that output. The only question was whether the oil handling and loading facilities could take this enormous overload. Careful engineering studies were made, and as part of these, a catastrophe fire survey was undertaken.

This was my introduction to the Middle East and the fantastic volumes of oil that are handled there. What was done to raise the level of fire protection was based not on the value of isolated wells and pump-houses but on the effect that a fire would have on the daily shipment of a million barrels of oil, the profit on which (shared 50-50 with the Shaikhdom of Kuwait) was said to be about $1.60 a barrel. Wherever possible water was made available for deluge systems for the equipment that handled the oil, equipment that could not be replaced in case of fire in less than a year's time.

I found a completely British fire organization in Kuwait, staffed by some of the most capable fire officers I have ever met. Their cooperation was complete and was reciprocated by sending the Fire Master to the United States for an intensive review of American oil company fire facilities and organizations. It is a credit to these men that not once in the history of this company has there been an interruption to production as a result of a fire.

There have been some sad occasions where fire training of plant personnel had not been given and where, as a result, fires have gotten away. One of these was in Baghdad last summer, shortly after the revolution in mid-July. A large bulk oil depot in that city was run by a local staff, under a Government oil authority. One afternoon, as a result of an error of some sort, a large cone-roofed steel tank blew its roof and took fire.

A tank fire is not necessarily a great problem, if men are trained and equipment is available. In this case there

was no equipment other than the Baghdad municipal fire department. A trained American crew, together with foam compound and special applicators were brought from a nearby refinery. But in the confusion and hostility resulting from the recent revolution, the American crew never got to the fire site and were lucky to escape with their lives. As a result, the fire slowly travelled from tank to tank until the entire plant was lost.

One of the great problems in the Middle East is that the oil horizons are both prolific in volume and high in pressure. Consequently exploratory wells sometimes take fire and there has been a series of these, amounting roughly to one each year or two, that have had to be capped or killed by extraordinary techniques. Mr. Myron Kinley of Houston, Texas, and his two assistants, have individually been called out on practically all of these fires and have never failed in their tasks. The skill and courage of these men can hardly be appreciated unless one has actually seen them in operation.

There have been a few lightning fires on a particular design of floating roof that gave some concern, although the fires were small and easily extinguished. They apparently resulted from lightning induced static charges, not direct hits, and have been overcome by simple modification of the roof design.

Generally speaking, the oil companies provide the most modern facilities and in some cases maintain elaborate municipal type fire departments, in addition to training their plant personnel as auxiliaries. The reason for these elaborate installations is that the employee camps are large and usually have no fire service other than that supplied by the company. A notable exception is the City of Kuwait, which has not only a municipal department but an airport crash unit, all staffed by Kuwaitis. This city has also gone far in tearing down the date-matting houses that were once the only homes available to the poor, and has replaced them with concrete block houses.

What we from America have added to the protection of these immensely valuable facilities has been the training of the men on the job in handling small hose streams equipped with fog tips, so that they can confine if not extinguish incipient fires after an alarm has been given. Those of you who have ever introduced this system will agree with me that not only is it immensely valuable as a fire control technique but that it also pays large dividends in reducing fire incidence. Workmen trained in fire control simply have less fires than those untrained. Middle East fire protection in its oil facilities has always been good and I am glad that we have added one additional technique that is part of the American way of life.

The Bermudiana Hotel Fire

On the afternoon of September 4, 1958, a fire of undetermined cause destroyed the 30-year-old Bermudiana Hotel in Hamilton, Bermuda. There were no deaths, and injuries were minor. The property damage is estimated at £850,000 ($2,380,000).

Construction and Protection

The 142 ft. by 188 ft. 6-story and basement structure was constructed of stuccoclad stone walls, wood-joisted floors and a roof of concrete slabs on exposed steel framing with a built-up roof covering. The interior partitions were wood studs with a plaster finish. The two interior stairwells were open from the basement to the top floor. These stairwells were on opposite ends of the building; there were no fire doors at floor openings nor were there smoke barriers in the connecting corridors.

The Hotel's private fire protection system consisted of two 1½-inch hoses at each floor level, one in each of the

Based on a report furnished by W. Petty, Chief Fire Officer, Hamilton Volunteer Fire Brigade.

Wide World Photos

The fire which destroyed the unsprinklered Bermudiana Hotel in Hamilton, Bermuda, burned from the top down. The scene above was probably taken shortly after 6 P.M. judging from the progress of the fire. This was 1½ hours after the Fire Brigade was called and three hours after smoke was first noticed by an outsider who did not give the alarm.

two stairwells. These hose lines were supplied by a 700-gallon roof-mounted water tank. The tank was normally filled by an automatically controlled electric-driven 75- to 100-gallon-per-minute pump located in the basement. There was also a manually controlled electric-driven similar sized pump connected directly to the standpipe system. Both of these electric pumps had manually-started, gasoline-engine-driven standby pumps to take over in emergencies.

Portable fire extinguishers made up the rest of the fire protection equipment. There was no automatic sprinkler or fire detection system, no manual alarm or evacuation signaling system, no organized private fire brigade and no emergency fire plan for the hotel.

The Discovery of the Fire

About 3:00 P.M. an employee of an oil company in a nearby building noticed smoke that appeared to be coming from the roof of the Bermudiana Hotel, but, because she saw a workman on the roof, thought no more about it. The workman was evidently unaware of the smoke as he later stated that he neither smelled nor saw smoke while he was on the roof or as he shortly thereafter went through the attic space on returning to the interior of the hotel. About 3:50 P.M. the oil company employee saw the smoke getting worse and called it to the attention of her coworkers. Sometime between 4:00 and 4:15 P.M. one of the women called the hotel to see if they were aware of the fire.

Upon receipt of the call the hotel telephone operator immediately passed the message on to the assistant hotel manager. The assistant manager told the operator to call the building engineer and reports he also told the operator to call the fire department. He then went quickly to the sixth floor.

Arriving on the top floor the assistant manager at first could neither see nor smell smoke but as he approached one end of the top floor be began to smell smoke. When he opened an attic ladder closet, he saw smoke: sticking his head into the attic space, he could see flames.

His first effort was an attempt to discharge an extinguisher on the flames. However, this attempt failed because he did not operate the extinguisher properly. He was able to operate a second extinguisher, but it had little effect on the fire.

At this point the building engineer arrived, bringing a charged hose line from one of the standpipe outlets. He used this hose to direct a stream into the attic, but unfortunately the basement pump had not yet been started so the water pressure was very poor, amounting to only a few feet of head from the 700-gallon roof-mounted tank. A few minutes later the pump was started and water pressure improved considerably.

The assistant manager next checked the sixth floor room over which most of the flames in the attic space were concentrated. He found the room filled with smoke and, on breaking open a partition, he found flames which appeared to be spreading up through the concealed wall space.

The Alarm of Fire

After calling the building engineer, the hotel telephone operator tried to call the fire department. She reported that she twice found the line "busy" and finally settled for a call to the police department. By this time even an announcer for Radio Bermuda had seen the fire from his studio and had broadcast this fact over the air. Still no one

As the night progressed the fire continued to move down through the building. With the delayed alarm, the fire had progressed beyond the capabilities of the fire equipment on the island. This loss is a vivid example of the need for automatic sprinkler protection in such properties.

had given the alarm to the Hamilton Fire Brigade, not even the police. By the time the police arrived, additional hotel employees and even some of the guests were working at the fire scene.

At 4:37 P.M., approximately 1½ hours after smoke was first seen by an outsider, a call was received by the station keeper at Hamilton Fire Brigade headquarters. A construction foreman at a nearby project had spotted the fire and turned in the alarm. The station keeper called the hotel to confirm the story and satisfying himself that it was not a false alarm sounded the general alarm signal.

The Fire Fighting

The first truck left the station three minutes after the alarm sounded and within 10 minutes the volunteers had three more trucks on the way. The station keeper ran to the street and seeing the seriousness of the fire called the Air Force Base (call received 4:50 P.M.) and the Fire Brigade in St. George's. The Air Force Base agreed to request additional help from the Naval Base.

The first arriving units of the Hamilton Fire Brigade found the roof and five rooms on the top floor well ablaze.

An electric company employee responding to the fire cut all electrical power to the building on his own initiative. This stopped the electric pumps, the elevator (which fortunately was not between floors) and cut off all the hotel's lights. The gasoline-powered emergency pump for the standpipe could not be started as the batteries were dead.

Some of the 215 guests registered at the hotel were stumbling around in dark corridors trying to find their rooms and their belongings. No warning was given them until about 5:00 P.M. when verbally relayed messages were passed through the Hotel advising all guests to leave.

At 5:05 P.M. the top floor corridor ceiling began to collapse.

Successive attempts to cut off flame spread were made by fire fighters on the two upper floors as the fire continued to burn down via the open stair shafts and within the concealed wall spaces. The weakened roof supports began to collapse about 5:20 P.M. as a stand was being planned for the fourth floor. This evidence of structural weakening forced the end of interior fire fighting. The fire then relentlessly consumed the entire building leaving only the walls and interior steel framing.

The assembled fire brigades used hydrants, two swimming pools and the harbor, only 300 feet away, to obtain water for their interior and exterior hose streams.

The Lessons

Though the exact origin and cause of this fire has not been established and probably never will be because of the extent of the damage, the lessons of this fire are not obscure.

The principal reason for the destruction of this large hotel was the lack of a complete automatic sprinkler system. Had this $2,000,000 structure been so protected not only would the alarm have been given early in the fire but also the fire would have been quickly extinguished if it originated in a room (as some believe) or would have been prevented from spreading into the rooms, corridors and attic if it started in a wall partition (as others believe).

Prime responsibility for delayed fire department notification in any fire cannot be placed on outsiders who see smoke and for one reason or another do not give the alarm. Hotel employees who delay fire department notification while they investigate or try to fight a fire by themselves could probably be accused of criminal negligence in event of subsequent legal actions. In the inquiry conducted on this fire, considerable criticism was levelled at the hotel management for their preparedness shortcomings and their failure to take positive steps to report the fire to the Brigade.*

The confusion of the guests resulted directly from the failure of hotel management to provide any type of manual fire alarm system to notify occupants that the building had to be evacuated. The fact that no lives were lost can be attributed to the fact that some hotel employees spontaneously searched each floor from the top to bottom, room by room, before the building became untenable. If the fire had occurred while the guests were sleeping or during hours of complete darkness, it is frightening to think what might have happened.

The stair shafts should have been enclosed not only to slow the vertical fire spread, as in this case, but also to provide safe exitways.

The electricity should have been controlled from the basement switchboard in such a manner as to leave power on for the pumps, the elevators, and the corridor and stair lights or these essential services should have been supplied from a separate emergency power source. Definite arrangements should be made so that utility company employees will consult with the fire official in charge of the fire before interrupting service.

*An outline for Hotel Emergency Organization can be found in Section 51 of the Building Exits Code (NFPA No. 101).

Carbon Dioxide Flows in Pipes and Nozzles

By H. V. Williamson, Director of Research
Cardox Division of Chemetron Corporation
Member, Society of Fire Protection Engineers

There has always been an element of mystery regarding the flow of carbon dioxide through the distribution piping of a carbon dioxide fire extinguishing system. The pressure drop through the piping was an illusive factor that seemed to make no more sense than the question of which orifice size to use. This well-kept secret could only exist because of the vast difference between the characteristics of carbon dioxide and common noncompressible fluids such as water.

The flow of water in a pipeline is accompanied by a uniform pressure drop for each increment of pipe. The pressure drop with carbon dioxide is nonlinear and increases rapidly near the end of the pipeline. The effect of temperature on the flow of water is negligible as long as the water does not freeze or boil. Temperature is very important in carbon dioxide flow, because it affects the pressure as well as the ratio of liquid to vapor in the pipeline. The flow of water through an orifice is controlled only by the pressure at the orifice. The flow of carbon dioxide through an orifice is controlled not only by the pressure at the orifice but also by the pressure in the storage container.

Carbon dioxide seems to be as changeable as one of the fair sex and yet it must follow the immutable laws of physics. Water and carbon dioxide differ in characteristics because water is an unchanging hydraulic fluid of constant density while carbon dioxide becomes a variable two-phase mixture of liquid and vapor in the pipeline. Something similar would happen to water if it were stored in a pressure vessel and heated to a high temperature so that it could be expelled by its own steam pressure.

Self-Energized Flow

One of the virtues of carbon dioxide is the fact that its normal saturation pressure is just right for self-energized flow through pipelines and nozzles. Saturation pressure refers to the boiling pressure or the liquefying pressure at any given temperature. At 0° F. the saturation pressure is about 300 pounds per square inch absolute (psia). At 44° F. it is about 600 psia and at 74° F. it is about 900 psia. The maximum saturation pressure of 1,072 psia would occur at the critical temperature of 87.8° F. when the filling density* is about 47 percent. Normally a cylinder is charged to 68 percent density and is completely full of liquid at about 80° F. A further increase in temperature will result in "super" pressures above the normal saturation level.

The pressure in the storage container supplies energy to expell the liquid through a dip tube terminating near the bottom. As liquid flows out, the remaining portion must expand to fill the container volume. The liquid boils so as to produce vapor bubbles which rise to the surface. As the vapor portion expands, some of it is condensed to liquid droplets which fall back to the liquid surface. This expansion takes place at constant entropy since work is

Based on an address by the author at the 63rd NFPA Annual Meeting held June 1-5, 1959 in Atlantic City, N. J.

*Filling density is the percent ratio of the weight of the gas in a container to the weight of water the container will hold at 60°F.

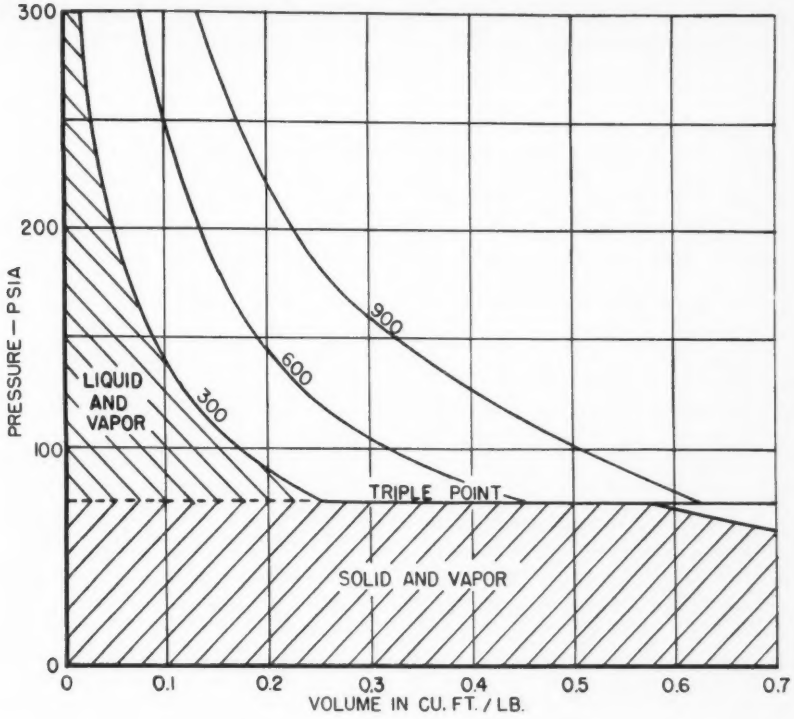

Figure 1. Free Expansion of Liquid CO_2

being done in expelling the liquid portion from the container. The main point is that there is a steady reduction of pressure during the process. The average pressure is therefore substantially less than the initial storage pressure.

The carbon dioxide enters the pipeline as a liquid at saturation pressure. At this point there is some energy loss due to friction in the pipeline. This causes a slight reduction in pressure and the liquid boils so as to produce a mixture of liquid and vapor. As the pressure continues to drop in the pipeline the volume of the liquid and vapor mixture becomes greater and greater. This is illustrated on Figure 1 for saturated liquid leaving the storage container at 300 psia. The expansion in the pipeline takes place at constant enthalpy since no energy is removed or added. This is usually called "free expansion" as opposed to "work expansion" against a moving piston or through a turbine.

At the triple point pressure of 75 psia there is a tremendous increase in volume due to the fact that the liquid flashes to snow and vapor. This region must be strictly avoided in the pipeline since the formation of snow would tend to block the discharge orifices in the nozzles. An interesting point here is that the area under the curve represents the approximate energy that is converted to velocity energy as the carbon dioxide is dis-

charged through the nozzle orifice. This energy must be used up through turbulence in the nozzle shell if a uniform low discharge velocity is desired.

The amount of expansion as the pressure is reduced is a function of the saturation pressure of the liquid entering the pipeline. When the saturation pressure is high the relative amount that is converted to vapor will also be high. For comparative purposes the volume at reduced pressures of liquid leaving the storage vessel at 600 and 900 psia is also shown on Figure 1. It is plain to see that the expanding volume of the carbon dioxide liquid and vapor will have a profound effect upon the pressure drop in the pipeline and also upon the discharge rate through an orifice.

The theoretical aspects are very interesting and rather involved technically. Our Assistant Director of Research, J. C. Hesson, was able to use this subject for his M.S. thesis and also his Ph.D. thesis from the Illinois Institute of Technology. His work provides a theoretical basis for computing flow conditions.

Discharge Rate Through Orifices

There is no simple equation to determine the discharge rate of carbon dioxide through an orifice as there is with water. The flow rate through an orifice must necessarily be a function of the pressure and also of the ratio of liquid to vapor present in the carbon dioxide entering the orifice. Since the situation is very complicated the desired information can be obtained only by actual testing under carefully controlled conditions. The information shown on Figure 2 was obtained in this manner by Hesson. This shows the discharge rate through an orifice having an area of 1 square inch. The test orifice had a well rounded inlet so that the hydraulic discharge coefficient was very nearly 100 percent. The theoretical discharge rate for water through the same orifice is also shown for comparison.

The upper envelope represents the flow rate that is obtained when carbon dioxide entering the orifice is 100 percent saturated liquid. It is interesting to note that the maximum flow rate is somewhat less than that obtained with water. This is because the carbon dioxide liquid tends to flash to liquid and vapor when passing through the orifice thus limiting the maximum flow. It is also interesting to note that the discharge rate for saturated liquid at 900 psia is considerably less than for 600 psia. The reason for this is the fact that the density of the liquid is considerably less at the higher pressure and there is probably a greater tendency to flash to vapor in passing through the orifice.

The bottom portion of the envelope represents the flow of saturated vapor through the orifice. The area within the envelope represents the flow rates obtained when saturated liquid is expanded to a lower pressure as would be the case when there is a pressure loss in flowing through a pipeline. For example, saturated liquid at 300 psia will flow through this nozzle at a rate of about 4,200 pounds per minute. If the pressure of the CO_2 entering the orifice is reduced to 200 psia by pressure drop in the pipeline, the flow rate will fall to about 1,100 lbs. per minute. This drastic drop in discharge rate is due to the fact that the carbon dioxide entering the orifice at the reduced pressure contains a considerable amount of vapor along with the liquid.

Flow Rate Through Pipeline

It is apparent that the pressure drop in the pipeline is a very important factor in regard to the discharge rate through a given orifice at the end of the pipeline. The pressure drop in the pipeline is very

difficult to obtain through experimental data because of the many variables that are difficult to control. However, the physical and thermodynamic information is available and a theoretical equation has been developed giving the relation between flow rate, pipe diameter, equivalent length and pressure conditions. There is no point in going into the development of this equation at this time except to say that it has been proven to be quite satisfactory by comparison with test results.

The theoretical equation is not exactly simple and it cannot be solved directly for pipe diameter or pressure drop. Nevertheless, it can be conveniently used for plotting curves from which graphical solutions can be ob-

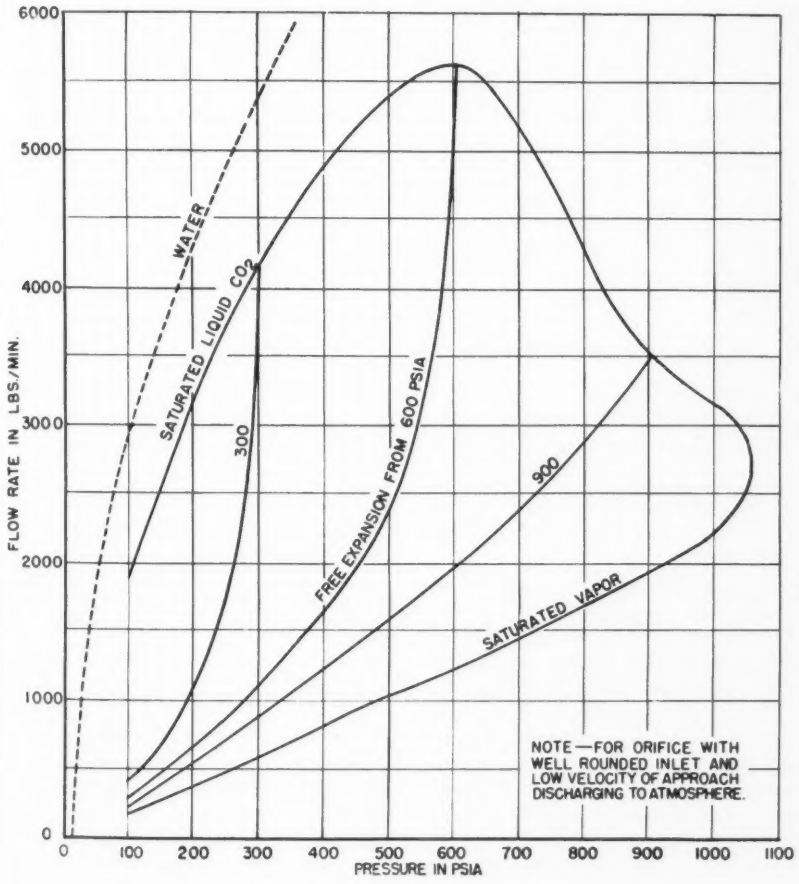

Figure 2. Discharge Rate Per Sq. In. of Orifice Area

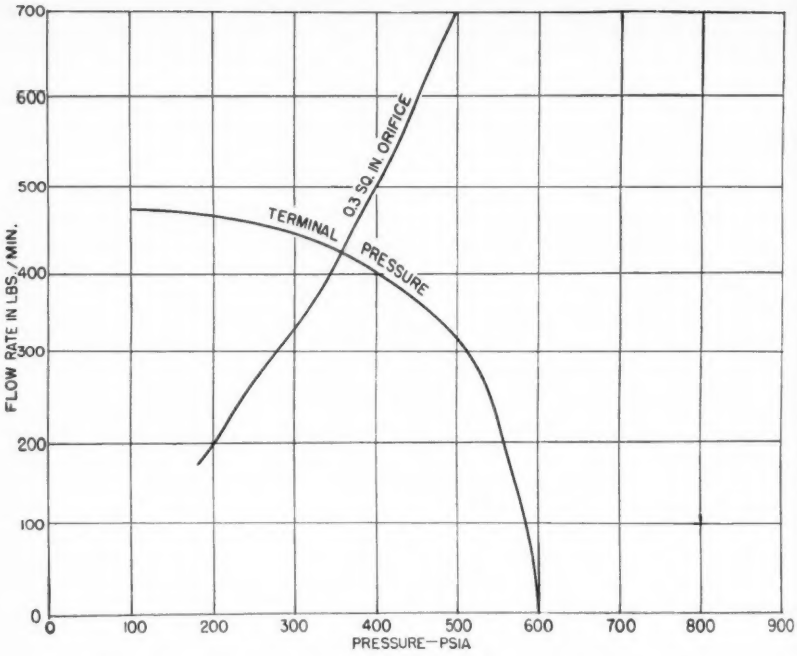

Figure 3. Flow Rate Through 200 Ft. of 1 in. Standard Pipe

tained. For example, Figure 3 shows the rate of flow plotted against terminal pressure for a 1 inch Schedule 40 pipeline with an equivalent length of 200 feet. This is based on a storage pressure of 600 psia.

For any given pipeline and orifice combination the flow rate will balance off at the point where the terminal pipeline pressure is just right to produce the same flow rate through the nozzle. To illustrate this, the flow rate through an orifice having an equivalent area of 0.3 square inches is superimposed on the terminal pressure curve. Both curves are, of course, based on the same starting storage pressure of 600 psia. It will be noted that the two curves intersect when the flow rate is about 420 pounds per minute. This is therefore the flow rate for this particular combination of piping and orifice area when the storage pressure is 600 psia.

If the storage pressure is changed, the terminal pressure and the flow rate will also change. On Figure 4, curves are plotted for storage pressure of 300, 600 and 900 psia. The intersecting points in each case show the flow rates that will be obtained at these storage pressures. These points have been connected with the dashed line to show the effect of storage pressure on the discharge rate.

The ratio of flow rates shown on Figure 4 will hold true only for this particular combination of piping and orifice size. In other words, the pressure drop in the pipeline follows a different pattern than the flow rate through the orifice. If the size of the orifice is

reduced we have in effect a new combination of pipeline and orifice size. This will result in somewhat lower flow rates and the ratio of flow as determined by storage pressure will not be quite the same as for the original orifice of 0.3 square inches.

Effect of Storage Pressure

On Figure 5 the effect of storage pressure is shown using the same piping system but using three different orifice sizes. The system with the large orifice shows the greatest change in flow rate when the storage pressure increases from 300 psia to 900 psia. The system with the smallest orifice shows the least change. As a matter of fact, the flow rate when the storage pressure is 900 psia is slightly less than when it is 600 psia. This can only happen when the pressure drop in the pipeline is very small. In a practical sense the average system will be designed to obtain maximum flow with a given size of piping. It would be uneconomical to install an oversized pipe with an undersized nozzle.

To completely analyze the effect of storage pressure, a common denominator is needed to specify the relationship between the piping and the orifice size. It so happens that the existing nozzle pressure at some standard storage pressure can be used for this purpose. If 300 psia is selected as the standard or base storage pressure, the nozzle pressure for the 0.3 square inch orifice will be about 185 psia. Any combination of piping

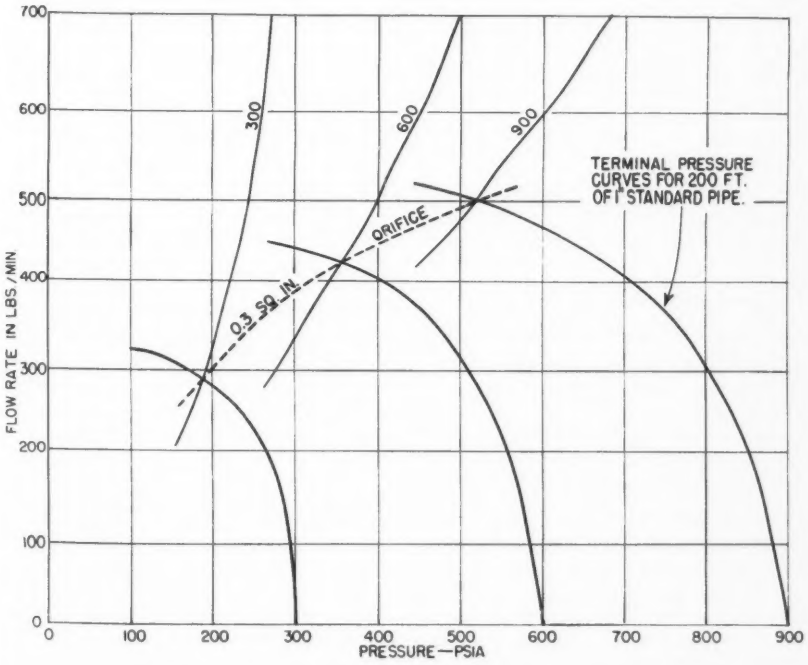

Figure 4. Effect of Storage Pressure on Flow Rate

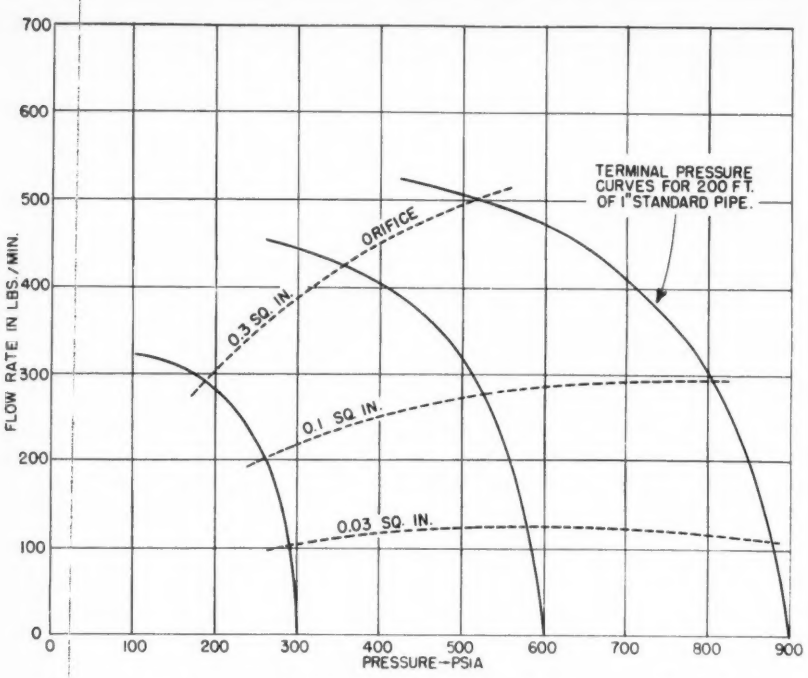

Figure 5. Combined Effect of Orifice and Storage Pressures on Flow Rates

and discharge orifice that gives this same nozzle pressure will be effected in the same ratio by changes in storage pressure.

Effect of Storage Temperature

On Figure 6, this relationship is used to show the effect of storage temperature on flow rate ratio for any combination of piping and orifice size. The horizontal scale is plotted in terms of nozzle pressure when the system is designed on the basis of 300 psia storage pressure. The vertical scale gives the ratio of flow rate as compared to the design flow rate. The temperature lines shown indicate the storage temperature of the carbon dioxide supply. The flow rate ratio is based on the average pressure during the discharge of the liquid portion from the storage container.

An interesting point is the fact that for very high nozzle pressures (low line loss) there is less change in flow rate. The end points where the nozzle pressure is 300 psia indicate a system that has no pressure drop in the pipeline. In other words, the orifice would have to be located right in the bottom of the storage container. The information for this condition comes from the liquid envelope for the orifice discharge data shown on Figure 2. It can be assumed that most fire extinguishing systems will operate in the nozzle pressure range near 200 psia.

Since the effect of temperature is predictable, there is apparently no need to calculate flow rates for more than one storage pressure. This calculation could be made for a storage temperature of

70° F, 32° F or for the 300 psia pressure which represents a storage temperature near 0° F. It is better to base calculations on the lowest expected storage temperature so that the minimum flow rate will be accurately known. Furthermore, this will provide information on the lowest expected nozzle pressures so that freeze-up conditions due to low pressure can be avoided.

Practical Design Viewpoint

So far we have investigated the discharge rate through an orifice, the terminal pressure and discharge rate through a pipe and orifice combination, and the effect of storage temperature on the discharge rate. The next problem is to determine how this information can be applied to the practical design of a fire extinguishing system. In an actual situation we would have several bits of information that must necessarily be predicated on the nature of the fire hazard itself.

In the first place, the number of nozzles and their location depends on the nature of the fire to be extinguished. The number of nozzles might be varied depending on capacity rating; however, each nozzle will have an optimum discharge rate in accordance with its function in extinguishing the fire. This

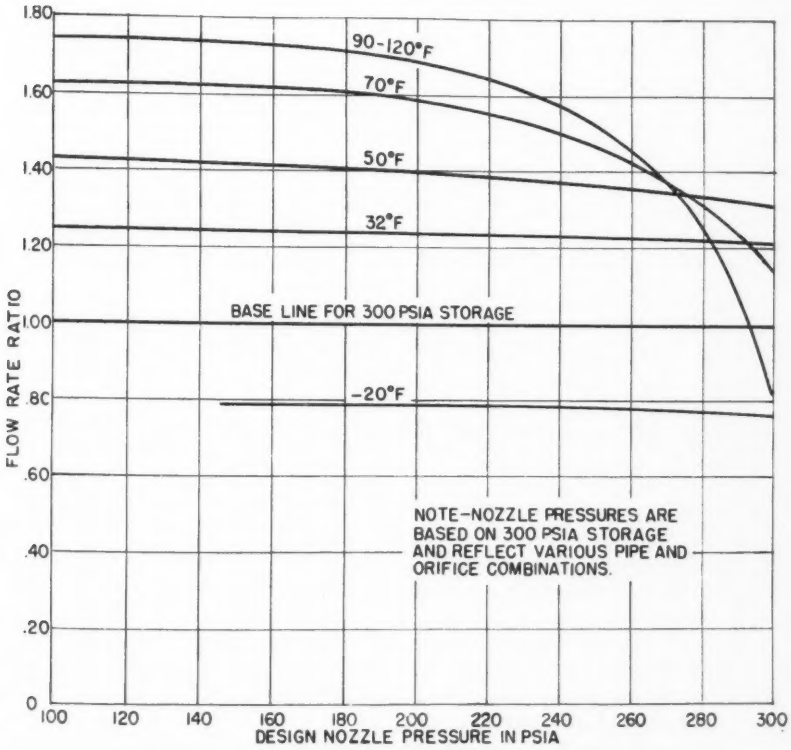

Figure 6. Effect of Storage Temperature on Flow

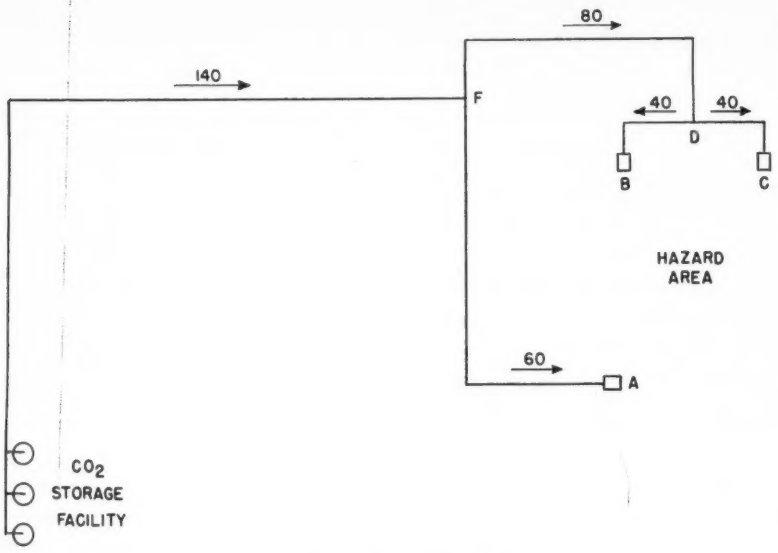

Figure 7. Typical System Diagram

tends to fix the required discharge rate at each nozzle and the total discharge rate. The total quantity of CO_2 is also determined by the nature of the hazard.

Secondly, the location of the CO_2 storage facility with respect to the hazard will be determined by the local conditions. This means that the length of the pipeline and the number of elbows and other fittings as well as the number of branch lines are pretty well fixed by the local requirements of the installation.

From this information it is possible to make a fairly accurate diagram of the piping system. A diagram of a typical system is shown on Figure 7. If nozzle A requires a flow rate of 60 pounds per minute and nozzles B and C require 40 pounds per minute, the flow in the main line must be 140 pounds per minute. The actual length of each section of pipe must also be determined from the plan. From this point it is the designer's job to determine the proper pipe sizes and the proper orifice size for each nozzle so that the system will discharge at the desired rate.

Before proceeding further, let's re-examine the flow rate problem. If the system is to be supplied with low pressure carbon dioxide, the storage pressure will always be near 300 psia. The flow rate will therefore remain constant regardless of ambient temperature changes. If high pressure storage is to be used, the storage pressure will be controlled by the ambient temperature. The flow rate will thus vary through a minimum and a maximum range depending on the expected temperature extremes. The minimum must not be too low for extinguishment and the maximum must not be too high.

Because of these variations we must think in terms of a range of flow rates.

This can be reduced to a design flow rate by adjusting to the storage pressure used to design the system. In this diagram we will assume that the noted flow rates have been adjusted for calculating purposes to design values based on a 300 psia storage pressure. By reference to Figure 6 this would be about two-thirds of the flow rate desired when the ambient temperature is 70° F.

Now, to get back to the problem of determining pipe sizes and orifice sizes. Pipe sizes can be arbitrarily assigned to the main line and each branch line subject to further checking. For the next step we must have a convenient method of determining the pressure at junctions F and D and at each nozzle.

Pressure Drop In Pipeline

Curves of terminal pressure versus flow rate, as shown on Figures 3, 4 and 5 are not particularly convenient for checking complex systems. It is better to use curves of line pressure plotted against equivalent length for constant flow rates. This makes it easier to determine line pressures through a wide range of equivalent length values.

A suitable chart for determining line pressures at any point in the line is shown on Figure 8. This is based on a storage pressure of 300 psia and a 1 inch standard weight pipeline. The solid lines are for various flow rates ranging from 100 pounds per minute to 500 pounds per minute. The dashed lines represent the equivalent orifice area that matches the intersecting flow rate line for the existing nozzle pressure.

The vertical and horizontal scales are not linear but instead have been adjusted so as to spread the working area over the whole chart. The vertical scale is based on one of the variables in the flow equation and tends to spread the pressure readings in degree of importance. In other words a pressure drop of 1 psi near the top of the scale is just as important as a pressure drop of 10 psi near the bottom.

The horizontal scale is based on the square root of the equivalent length. This spreads out the scale in the short equivalent length region and compresses the scale for long equivalent lengths. The equivalent length region below 10 feet has been omitted to save room. It is never used at any rate because the first valve will have an equivalent length greater than 10 feet.

With charts of this type it is a simple matter to determine the pressure at any point in the system. For example, if the flow rate in a pipeline is 250 pounds per minute and the equivalent length (starting from the storage vessel) is 200 feet, the terminal pressure as read from the chart will be 240 psia. If the line terminates in a nozzle at this point, the equivalent nozzle area would have to be slightly greater than 0.15 square inches to discharge at the rate of 250 pounds per minute.

Obviously, a separate chart is needed for each pipe size that may be used. However, this is all that is needed to analyze the pressure conditions in a proposed system and to determine the proper orifice area for each nozzle. The designer must start at the storage container and work down to the nozzles. The pressure at the end of the first section will be the starting point for the next section which may be a branch line with a different flow rate and a different pipe size. If the final nozzle pressures are too low or too high, it will be necessary to adjust pipe sizes and start over.

Explanation of Terms Used

You have probably noticed that all pressures are given in terms of absolute pressure rather than gage pressure. This was done because the flow equation is necessarily based on absolute pressure.

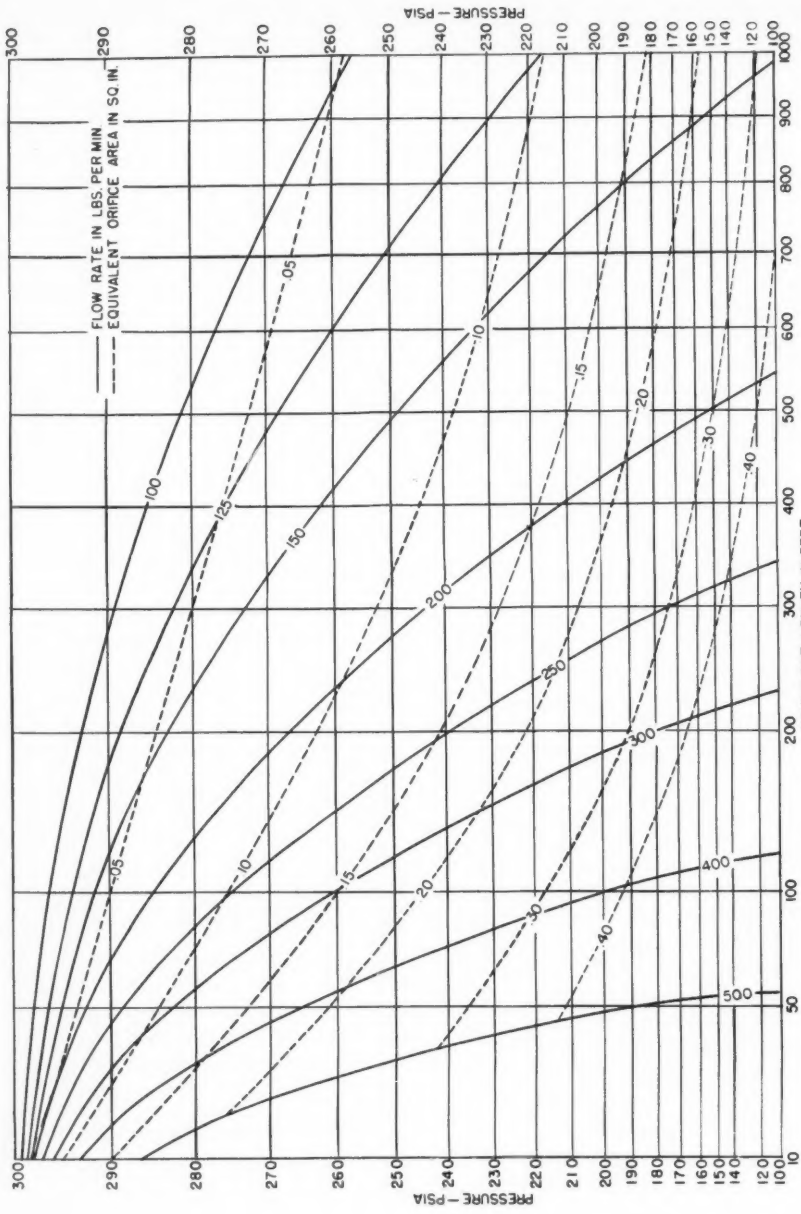

Figure 8. CO_2 Flow Chart for 1 in. Standard Weight Pipe

From a design viewpoint it doesn't matter as long as the orifice data is expressed in the same terms. It is important only when attempting to compare test data with theoretical calculations.

The correct use of the term "Equivalent Length" is of much greater importance. The actual length of a valve or an elbow is negligible; however, the pressure drop through it will be equal to the drop through a substantial length of straight pipe. This is called the equivalent length of the valve or fitting. The equivalent length of the pipeline is thus the actual length plus the equivalent length of any valves and fittings or other restrictions in the line.

The correct use of the term "Equivalent Orifice Area" is also important. The orifice flow data is based on a near perfect orifice with a well rounded inlet. It is also based on a relatively small orifice with respect to pipe diameter so that the velocity of approach is negligible. Orifices actually used will generally have square edge inlets. Furthermore, the size and geometric location with respect to the pipe will vary. For this reason it is necessary to rate the nozzle orifice in terms of an equivalent diameter or area that matches the flow data. Thus the equivalent area may be smaller or even greater than the actual area.

Conclusions

To summarize, we now have sufficient information to design CO_2 distribution systems on a performance basis. The piping need not be balanced or symetrical with respect to branch lines. There is no need to apply flat limitations to the length of the pipeline. There is no need for empirical limitations on valve sizes and orifice areas.

Those who must inspect and approve installations have a problem. If relative orifice areas and pipe sizes, as used in the past, do not tell the full story, just what are you going to inspect. I look forward to probable changes in the NFPA Standard for Carbon Dioxide Extinguishing Systems (NFPA No. 12). The listing laboratories will probably be testing components for new information such as the equivalent length of valves and the equivalent area of nozzle orifices.

It has not been possible in this short article to cover all of the details relating to piping design. Omitted are comments on such items as flow velocity effects and time for liquid to reach the discharge nozzles. This information will be made available to the NFPA Carbon Dioxide Committee and the listing laboratories for whatever use they may wish to make of it.

Addendum

The theoretical equation for the flow of saturated liquid carbon dioxide in pipelines was not discussed for obvious reasons. For those who may be interested, one form of the equation is as follows:

$$Q^2 = \frac{3647\ D^{5.25}\ Y}{L + 8.08\ D^{1.25}\ Z}$$

where Q = Flow rate in lbs./min.
D = Inside pipe diameter in inches.
L = Equivalent length of pipeline in feet.

$$Y = -\int_{P_1}^{P} \rho dP$$

$$Z = -\int_{\rho_1}^{\rho} \frac{d\rho}{\rho} = \ln \frac{\rho_1}{\rho}$$

P_1 = Pressure in psia entering pipeline.
P = Pressure in psia at the end of pipeline.
ρ_1 = Density at pressure P_1 in lbs./cu. ft.
ρ = Density at pressure P in lbs./ cu. ft.
ln = natural logarithm

The Y and Z factors depend on storage pressure and must be evaluated for various reduced pressures. This is best done by graphical methods using thermodynamic tables to compute and plot curves of density versus pressure assuming free expansion as the pressure is reduced. Once the

Y and Z factors have been determined for a given storage pressure, the equation is relatively simple to use for plotting curves of flow rate versus terminal pressure or line pressure versus equivalent length. Y and Z factors for a storage pressure of 300 psia are listed below.

P	*Y*	*Z*
300	0	0
290	603	0.12
280	1138	0.24
270	1613	0.36
260	2033	0.48
250	2406	0.60
225	3163	0.90
200	3723	1.20
175	4137	1.50
150	4443	1.80
125	4670	2.11
100	4837	2.41

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1. Air Conditioning Refrigerating Data Book (Design) — The American Society of Refrigerating Engineers.

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3. Hesson, J. C., "Pressure Drop for Two-Phase Carbon Dioxide Flowing in Pipelines," unpublished M.S. Thesis, Illinois Institute of Technology, 1953.

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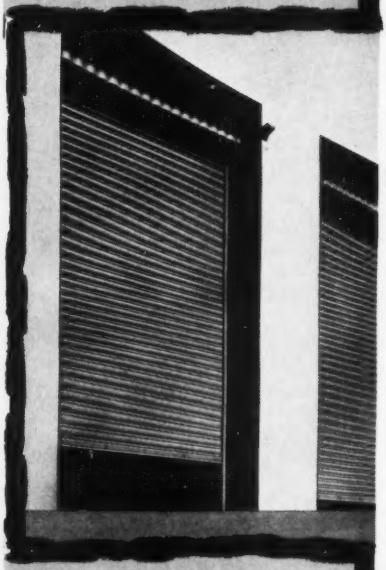

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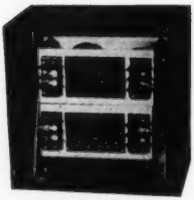

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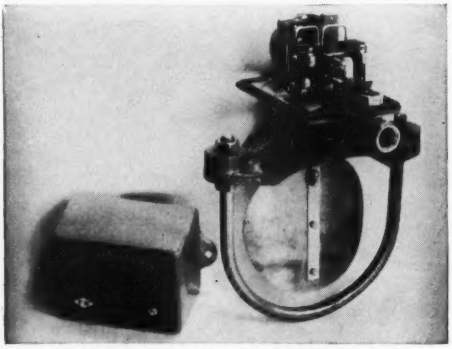

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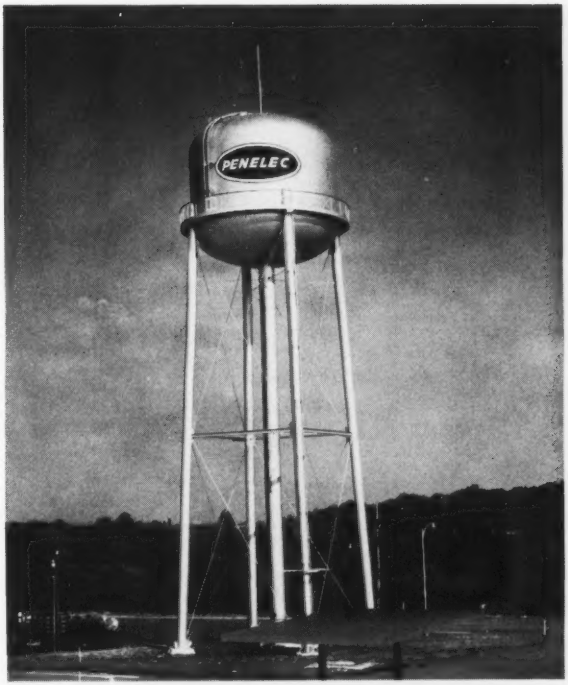

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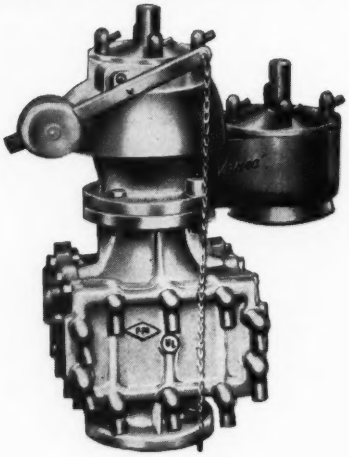

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By actual records of the National Fire Protection Association there has never been a loss of life in a completely sprinklered school. Sprinkler systems have been effective either in completely extinguishing the fire or holding it in check. These are facts.

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The Rockwood Sprinkler Company has a staff of scientifically trained fire-fighting experts that will be happy to meet you or your committee to give full information and advice on how an engineered sprinkler system can save lives and property. Call the Rockwood fire engineer nearest you.

ROCKWOOD SPRINKLER COMPANY

Engineers Water . . . to Cut Fire Losses

Tested and listed by Underwriters' Laboratories, Inc.

BOSTON, MASS.
Phone: HAncock 6-6250

BUFFALO, N. Y.
Phone: Cleveland 3233

CHARLOTTE, N. C.
Phone: EDison 3-1094

CHICAGO, ILL.
Phone: WEbster 9-2507

CINCINNATI, OHIO
Phone: UNiversity 1-7415

CLEVELAND, OHIO
Phone: MAin 1-5086

DETROIT, MICH.
Phone: WOodward 1-0679

GRAND RAPIDS, MICH.
Phone: GLendale 9-3060

HOUSTON, TEXAS
Phone: JAckson 8-0989

INDIANAPOLIS, IND.
Phone: MElrose 7-0303

KANSAS CITY, MO.
Phone: JEfferson 1-5799

LOS ANGELES, CALIF.
Phone: PLeasant 9-9161

MEMPHIS, TENN.
Phone: JAckson 6-7856

MILWAUKEE, WIS.
Phone: FRanklin 2-0260

MINNEAPOLIS, MINN.
Phone: TAylor 7-3801

MONTREAL, QUE., CANADA
Phone: REgent 8-9476

NEWARK, N. J.
Phone: MArket 2-2085

NEW ORLEANS, LA.
Phone: TWinbrook 7-2637
TWinbrook 7-2638

NEW YORK, N. Y.
Phone: BEekman 3-2836
MArket 2-2085

OSHKOSH, WISC.
Phone: BEverly 1-1940
BEverly 1-1941

PHILA. (JENKINTOWN), PA.
Phone: LIvingston 8-5430
Local
TUrner 4-5063
Long Dist.

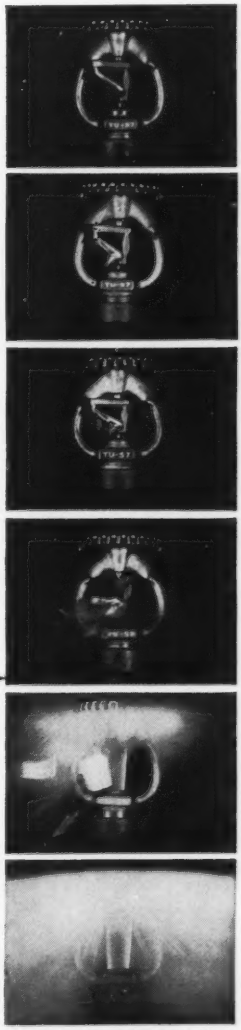
PHOENIX, ARIZ.
Phone: ALpine 3-9709

PITTSBURGH, PENN.
Phone: LEhigh 1-1661

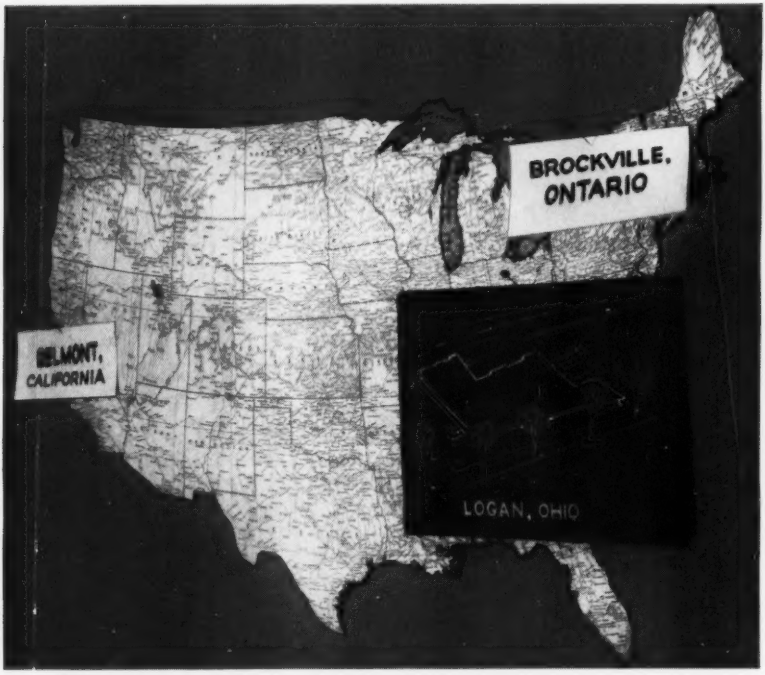
SAN MATEO, CALIF.
Phone: DIamond 2-7246
DIamond 2-7247

SEATTLE, WASH.
Phone: MUtual 2-1450
MUtual 2-1451

ST. LOUIS, MO.
Phone: CEntral 1-3610-11



One-tenth of a second after the solder melts on this Rockwood Sprinkler head, water sprays out to extinguish or control the fire — *all automatically!*



METALBESTOS
PUTS ANOTHER PLANT ON ITS VENTING MAP

All-fuel Chimney Section

Gas Vent Pipe Length

A significant addition to the Metalbestos marketing network, this new plant in Logan, Ohio, is scheduled for mid-1959 completion. It follows closely on the heels of another production facility established last year: The Metalbestos Manufacturing Company in Brockville, Canada.

At its new Ohio plant Metalbestos will manufacture a complete line of gas vent and all-fuel chimney products. The result will be to expedite distribution and service to eastern, southern and midwestern customers.

In the words of William Wallace Company president, Alan Kinkead, "This is an important new link in our chain of plants, warehouses and factory representatives. It should materially assist those engaged in serving North America's heating needs."

METALBESTOS DIVISION
WILLIAM WALLACE COMPANY · BELMONT, CALIF.

Where there's smoke...

it's almost certain one or more of the dependable, high-quality fire fighting products... known by these famous brands... will be called upon to fight the fire!

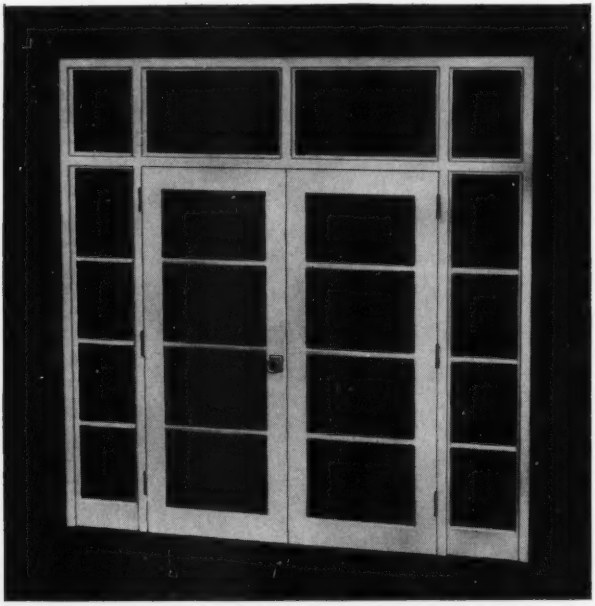
Consolidated under a single organization, these brands comprise the most complete line of competitively-priced fire protection products and services ever offered. This means you can guard against every fire risk by contacting a single source for all these products: approved fire extinguishers; automatic sprinkler systems; carbon dioxide, dry chemical and foam systems; fire hose, nozzles and couplings; alarm systems; and fire department accessories including ladders, sirens, clothing, breathing apparatus, first aid kits, etc.

Representatives of this broad product line, with their depth of knowledge and experience in all industrial, commercial, institutional, municipal and household fire hazards, are uniquely qualified to *survey, analyze* and *recommend the proper equipment* for every fire protection requirement. To contact the representative nearest you, look in the yellow pages under "Fire Protection Equipment" or write to:

THE FYR-FYTER COMPANY

ATLANTIC COAST REGIONAL OFFICE
P. O. Box 750, Newark 1, New Jersey
CENTRAL STATES REGIONAL OFFICE
221 Crane St., Dayton 2, Ohio
PACIFIC COAST REGIONAL OFFICE
132-140 Hawthorne St., San Francisco 7, Calif.

BRANCHES: Atlanta, Baltimore, Boston, Chicago, Dallas, Dayton, Detroit, Los Angeles, New York, Newark, Philadelphia, Pittsburgh, Portland, Rochester, San Francisco, Seattle, Toronto (Ontario). Representatives and Distributors in all principal cities.



FIRE BARRIERS BY OVERLY ALLOW MORE TIME FOR SAFE EVACUATION

To prevent the disastrous flash spread of fire, Overly has developed and obtained UL approval on a unique smoke screen fire door and frame assembly. Used to subdivide long corridors and enclose stairwells, the Overly smoke screen will bar the progress of fire, smoke and heat for a minimum of 45 minutes — more than ample time to permit safe exit.

Get the graphically illustrated story of how adequate fire barrier protection in your schools can save lives. Send for a free copy of the folder shown at right. Write us today.

■ A new eight-minute color film—Fire Barriers by Overly—is available for group showings. We shall be happy to arrange a presentation.

OVERLY MANUFACTURING COMPANY

GREENSBURG, PENNSYLVANIA • LOS ANGELES 39, CALIFORNIA

Champion Fire Fighters

COMPRESSION TYPE FIRE **HYDRANT**

MH

Above all else, M & H Fire Hydrants are reliable and dependable fire fighting equipment. They deliver when the need arises, if there is water in the mains. Their high flow efficiency is due to an unobstructed, large waterway which has the same diameter its entire length.

Dry top, dry barrel when not in use, eliminates danger of damage by freezing. Operating parts are bronze or bronze bushed. Easy to lubricate.

Manufactured according to A. W. W. A. standard specifications or Underwriters and Factory Mutuals approved; in conventional model, traffic model or flush-type model; sizes 4¼, 4½, 5¼ and 6¼. For complete information, address

M&H VALVE AND FITTINGS COMPANY
ANNISTON, ALABAMA

SUBSIDIARY OF W WALWORTH

STARGARD

GIVES YOU MORE — FOUR WAYS

UPRIGHT SPRAY SPRINKLER

PENDENT SPRAY SPRINKLER

APPROVED BY
FACTORY MUTUAL LABORATORIES

SIDEWALL SPRINKLER

LISTED BY
UNDERWRITERS' LABORATORIES, Inc.

SMALL ORIFICE SPRINKLER
(With Identifying Pintle)

1 **SUPERIOR PROTECTION** . . . due to more efficient water distribution. Proven by tests under actual fire conditions for all classes of hazards.

2 **MORE EFFECTIVE USE OF LESS WATER** . . . because wider distribution and break-up of the water discharged provides greater cooling and extinguishment.

3 **CEILING PROTECTION BY COOLING — NOT WETTING** . . . All the water goes onto the fire. The break-up of water results in complete cooling and control of flammable vapors.

4 **MORE FIRE CONTROL WITH FEWER SPRINKLERS** . . . because ceiling temperatures are kept lower, fewer sprinklers open. Immediate water saturation of the fire area prevents the spread of fire. Hot gases become impotent in the cooled atmosphere.

STAR SPRINKLER CORPORATION

Westmoreland & Collins Sts., Phila. 34, Pa.

Licensees in principal cities of the United States and Canada

VICTAULIC

METHOD OF PIPING

VICTAULIC COUPLINGS

Styles 77, 77-D for standard applications. Simple, fast to install — sturdy and reliable. Sizes ¾" to 30". Style 75 Light-Weight Couplings for light-duty applications. Sizes 2" to 8". Additional styles for cast iron, plastic and other pipes. Sizes through 60".

ROUST-A-BOUT COUPLINGS

Style 99 for plain or beveled end pipe. Best engineered, most useful plain end joint on the market. Simple, husky — easy and fast to install. Takes strong bull-dog grip on pipe. Sizes 2" to 12".

VICTAULIC FULL-FLOW FITTINGS

Complete line of Elbows, Tees, Reducers, Laterals, etc. — to fit all Victaulic Couplings. Streamlined for top efficiency, easy to install. Sizes ¾" to 12".

VIC-GROOVER TOOLS

Handy, on-the-job grooving tools that do the job in half the time. Light weight, easy to handle — operate manually or from any power drive. Automatic groove position and depth. Sizes ¾" to 8".

APPROVED BY:

Underwriters' Laboratories, Inc.
Factory Mutual
New York City Board of Standards and Appeals, Cal. #413-53-SM.

Proven for 28 years on both wet and dry Fire Protection Systems. Standard with most major sprinkler companies for bulk-run and cut-in piping. Victaulic Couplings are installed in *less than one-half the time* required for other standard pipe joints.

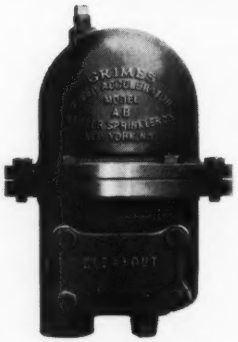
THE EASIEST WAY TO MAKE ENDS MEET

VICTAULIC

COMPANY OF AMERICA
P.O. Box 509, Elizabeth, N. J.

NEW IMPROVED GRIMES MODEL AB SUPER ACCELERATOR

SPEEDS UP DRY PIPE VALVE OPERATION



ALL BRONZE

EASY TO INSTALL

SIMPLE TO SERVICE

FIRE SPRINKLER SYSTEMS AND EQUIPMENT

Engineered for better protection

ALARM VALVES
WATER MOTORS
VALVE DEVICES
DRY PIPE VALVES
RETARD CHAMBERS
CIRCUIT CLOSERS
EMERGENCY CABINETS
TRIMMINGS
SPRINKLERS — ALL TYPES AND FINISHES

WATCH FOR ANNOUNCEMENT OF THE NEW GRIMES MODEL B DRY PIPE VALVE.

Write Now for Descriptive Literature.

There is a Grimes Licensed Representative near you who is equipped to design and install a fire sprinkler system to meet your specific needs.

Grimes Devices are approved by all Insurance Interests.

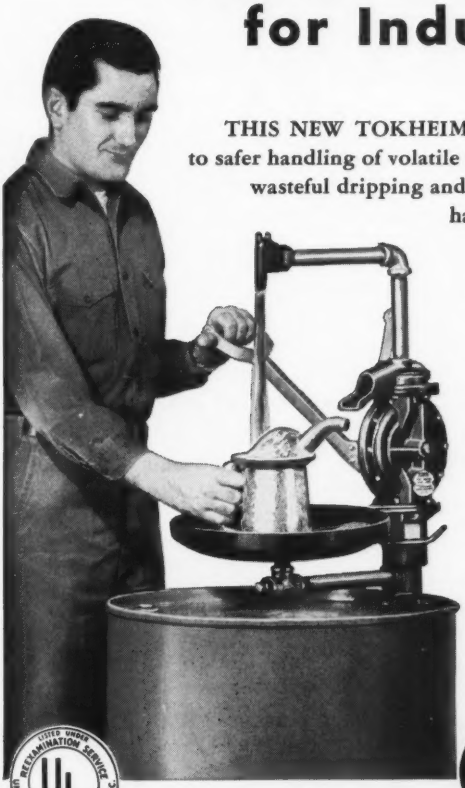
RAISLER
SPRINKLER DIVISION

RAISLER CORPORATION, 750 Third Ave., New York 17

Licensees in all principal cities in the United States and Canada

SAFER

liquid handling for Industry



THIS NEW TOKHEIM HAND PUMP contributes to safer handling of volatile liquids wherever used. Stops wasteful dripping and slippery floors. Reduces fire hazard and accidents common to other methods of liquid transfer. Approved for handling petroleum liquids —ideal for many others. Available in 22 different models for 'most any use— from pipe lines to drums, or underground tanks, with hose or spout outlets. Order from your dealer, your oil company, or your Tokheim representative.

Write factory for literature.

QUALITY TOKHEIM HIGH VACUUM HAND PUMPS

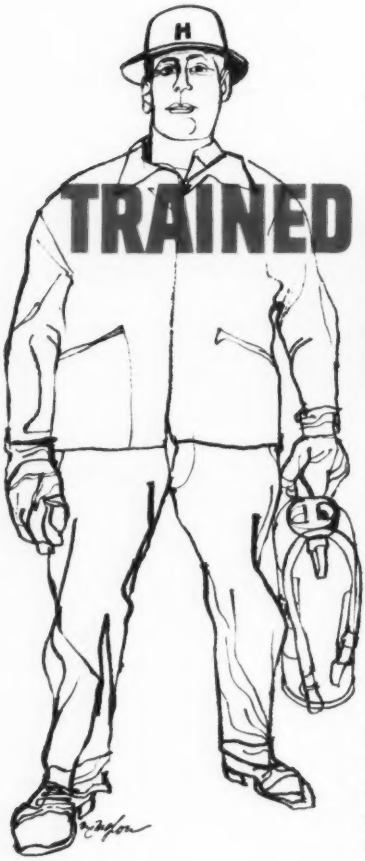
General Products Division

TOKHEIM CORPORATION

DESIGNERS AND BUILDERS OF SUPERIOR EQUIPMENT SINCE 1901

1686 WABASH AVENUE FORT WAYNE, INDIANA

Subsidiaries: Tokheim International, A. G., Lucerne, Switzerland; GenPro Inc., Shelbyville, Indiana; Tokheim of Canada, Ltd., Toronto, Ontario



IN FIRE EMERGENCIES

TRAINED PEOPLE MAKE THE DIFFERENCE

Training your people is one of Ansul's most important jobs. In your own plant, at our Fire School in Marinette, Ansul experts instruct your men in the latest fire fighting techniques. This training is only part of Ansul's unique service program. In addition, you receive thorough fire protection surveys of your plant, visual aids to make your employees fire-prevention conscious. Trained men, fire prevention planning—plus Ansul fire extinguishing equipment give you the complete protection you need. Write us. Let us tell you about the Ansul service plan.

ANSUL CHEMICAL COMPANY / MARINETTE, WISCONSIN

FIRE EXTINGUISHING EQUIPMENT / INDUSTRIAL CHEMICALS / REFRIGERATION PRODUCTS / NATIONAL DISTRIBUTORS OF "FREON" REFRIGERANTS

NOW... Kuhns ductile iron fittings

For Sprinkler Systems

Kuhns ductile iron pipe fittings—the newest development in piping—provide an extra margin of operating safety for sprinklers, high pressure lines and other vital piping systems. High structural strength and resistance to thermal shock help these fittings prevent leakage caused by vibration, temperature changes or misalignment.

"K" Pipe Lock Couplings

Listed for 800 psi by Underwriters' Laboratories, Inc., these couplings have a safety factor of five times the UL listing for 2½" through 6" and four times UL listing for 8". Sizes: 2½" through 8". Look for the "800 D" on each.

"K" Flanges and Flanged Fittings

Pressure rating, 500 psi by Underwriters' Laboratories, Inc. for elbows, base elbows, 45° elbows, side outlet elbows, tees, side outlet tees, and reducers in straight and reducing sizes. Flat faced flanges standard. Extra heavy flange dimensions and raised faces available. Look for the "DI 500" on each.

Complete range of sizes through 12".

"K" Screwed Fittings *

Pressure ratings listed by Underwriters' Laboratories, Inc.

STEAM AND OIL AT 550°F

¼" to 3" . . . . . 300 lbs.

LIQUID AND GAS AT 150°F

¼" to 1" . . . . . 2000 lbs.

1¼" to 2" . . . . . 1500 lbs.

2½" to 3" . . . . . 1000 lbs.

Ductile iron fittings are available in any size in Kuhns complete cast iron line, ¼" through 12".

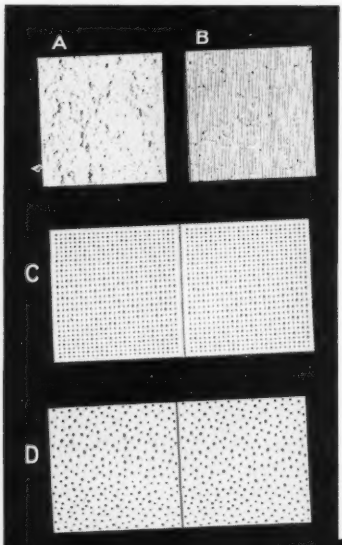
Note: These fittings are excellent for liquefied petroleum gas systems. Look for the "DI 300" on each.

Send for our catalog or contact your wholesaler.

THE KUHNS BROTHERS CO.

1800 McCALL STREET, DAYTON, OHIO

INCOMBUSTIBLE CEILING TILE
...and they're ALL "by CELOTEX"!



Here are just 7 examples of tile used in "Ceilings by Celotex" that meet building code requirements for incombustibility.

ALL ARE U.L. LISTED

A.—CELOTONE®
Fissured Mineral Fiber Tile

B.—STRIATONE*
Striated Mineral Fiber Tile

C.—STANDARD PERFORATED
Mineral Fiber Tile

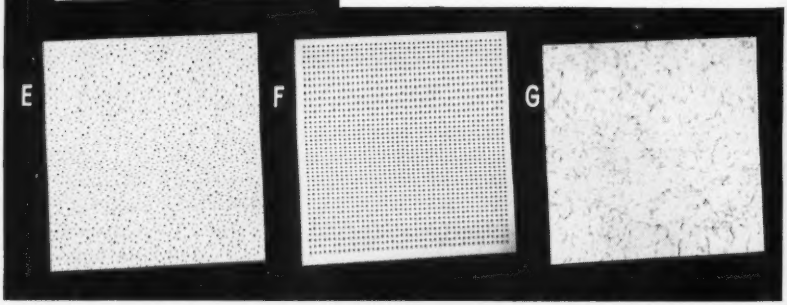
D.—RANDOM PERFORATED
Mineral Fiber Tile

E.—NEW RANDOM DESIGN
Perforated Mineral Fiber Tile

F.—CAVITY TILE
U.S. PAT. NO. 2838806

G.—SUPRACOUSTIC*
Glass Fiber Panels

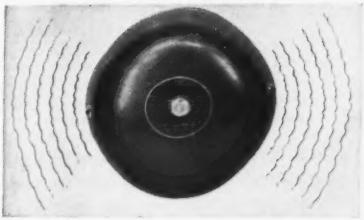
*Trade Mark



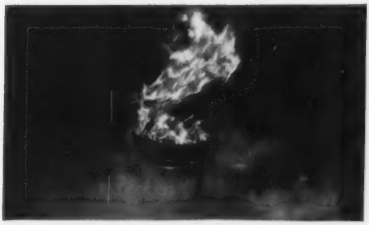
ACOUSTI-CELOTEX
REGISTERED U.S. PAT. OFF.
TRADE MARK
Sound Conditioning

Products to Meet Every Building Code
THE CELOTEX CORPORATION • CHICAGO 3, ILLINOIS
In Canada: Dominion Sound Equipments, Ltd., Montreal, Quebec

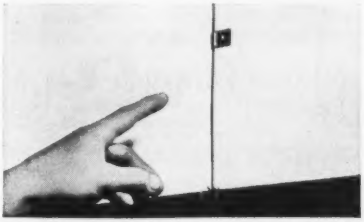
FIRE ALARM!



1. Save priceless lives, protect valuable buildings with the Kidde Atmo Fire Detecting and Alarm System!

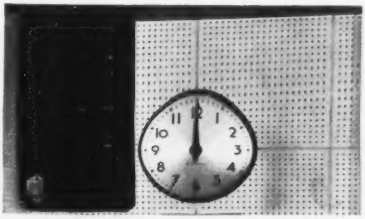


2. This automatic detecting and warning system sounds an alarm instantly at the *first* hot breath of fire!



3. Using rate-of-temperature-rise tubing as a sensing element, the system works without outside power!

4. Kidde's Atmo system can sound alarm at fire area, outside the building or at local fire department station!



5. Kidde's Atmo system also gives fire location at a panel near any manned telephone switchboard!

Kidde Atmo

KIDDE ULTRASONIC & DETECTION ALARMS, INC.
751 Brighton Road, Clifton, N. J.

A Subsidiary of
Walter Kidde & Company, Inc.
Belleville 9, N. J.

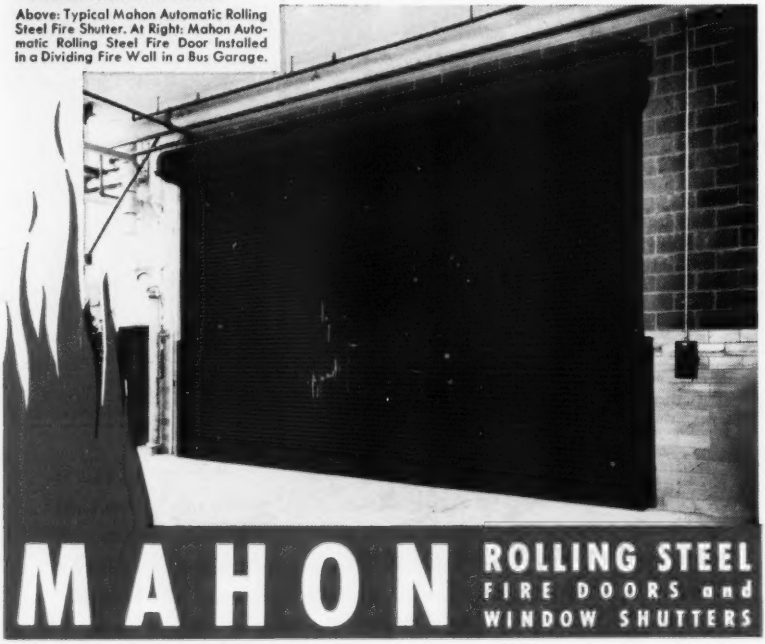
For fast, dependable fire detection and warning, install a Kidde Atmo Fire Alarm System. Ideal where life protection and early fire warning is essential, the Kidde Atmo system can also close doors, shut off fans, motors, blowers, is automatically re-setting after use or test. Get more information! Write today and ask for Kidde's Atmo Alarm Systems booklet!

Automatic Rolling Steel
FIRE DOORS *and* WINDOW SHUTTERS
PREVENT SPREAD *of* FIRE!

You need good automatic fire doors in fire walls, corridors, and vertical shafts . . . in some cases automatic rolling steel window shutters are necessary to protect your building and its contents from fires which may originate in nearby buildings. Many, many cases are on file which confirm that timely action of automatic rolling steel fire doors and window shutters have confined a fire to its point of origin and permitted its being extinguished with comparatively small damage. Make a survey of your building now, and don't delay action. You will find a Mahon Automatic Rolling Steel Fire Door or Window Shutter to meet each of your requirements—all bear the Underwriters' Label. These automatic fire doors may be operated manually or mechanically in every day use. If a fire should break out while they are in the open position, the automatic mechanism will close the door, cutting off drafts and preventing the spread of the fire. See Sweet's Files for complete information, or write for Catalog G-59.

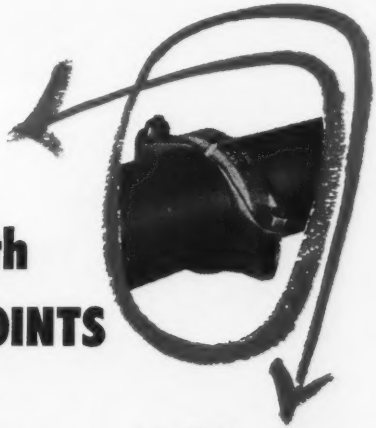
THE R. C. MAHON COMPANY • Detroit 34, Michigan
Branch Offices in New York and Chicago • Representatives in Principal Cities
Manufacturers of Standard and Underwriters' Labeled Automatic Rolling Steel Fire Doors and Window Shutters; Underwriters' Rated Metalclad Fire Walls; Insulated Metal Curtain Walls; Electrified M-Floors; Steel Roof Deck; Acoustical Long Span M-Decks; and Acoustical and Troffer Forms.

Above: Typical Mahon Automatic Rolling Steel Fire Shutter. At Right: Mahon Automatic Rolling Steel Fire Door Installed in a Dividing Fire Wall in a Bus Garage.



MAHON ROLLING STEEL FIRE DOORS and WINDOW SHUTTERS

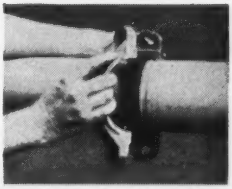
Couple Pipe the Easy, Low Cost Way with New G-B GRUVAJOINTS



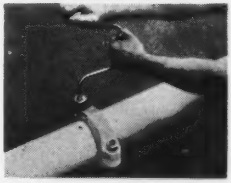
Now you can save up to 25% when connecting pipe for bulk runs and risers. Yes, contractors are saving money every day when they use new lightweight Gruvajoints. There's no flanging, no threading, no welding, and there's no need for heavy chain tongs or pipe wrenches. Gruvajoints are truly the modern way to couple pipe. Write today for free illustrated brochure on G-B Pipe Coupling Products. Gruvajoints are now available in 2", 2½", 3", 4", 5", 6" and 8" sizes.

Install Gruvajoints in three easy steps

Grease gasket and center over pipe ends.



Lay housing halves into grooves and insert bolts.

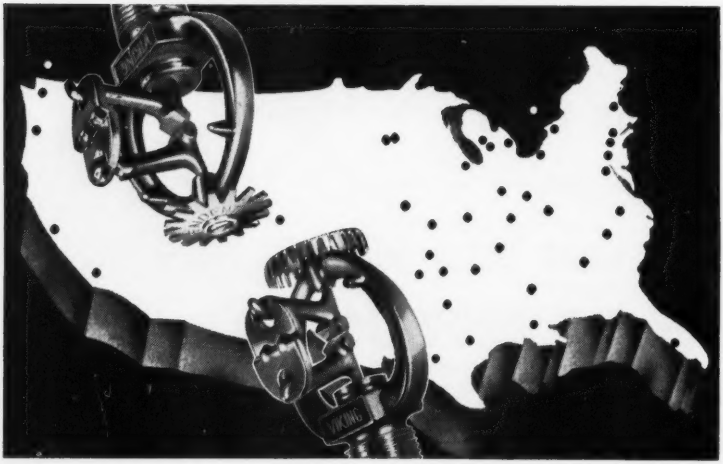


Tighten the two nuts equally.

LISTED by
Underwriters' Laboratories, Inc.
File EX 1741A and B

APPROVED by
Factory Mutual Engineering Division
Report Serial No. 13097

GUSTIN-BACON
manufacturing company
210 W. 10th St. Kansas City, Missouri



VIKING **FIRE PROTECTION**

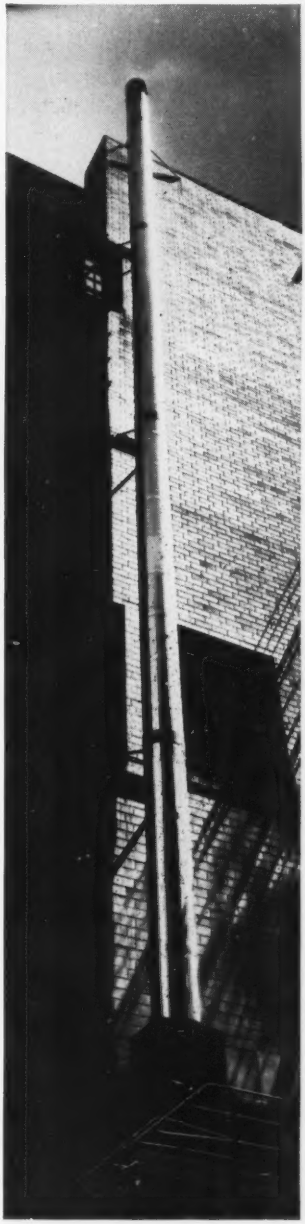
For fire control whatever it happens to be, call the nearest Viking Representative

ATLANTA — Crawford & Slaten Co. **BOSTON** — Viking Automatic Sprinkler Co. **BUFFALO** — Viking Automatic Sprinklers, Inc. **CHICAGO, MILWAUKEE** — Viking Automatic Sprinkler Co. **CINCINNATI, CLEVELAND, INDIANAPOLIS, LOUISVILLE** — Viking Sprinkler Co. **DALLAS, HOUSTON, JACKSON (Miss.), MEMPHIS, NEW ORLEANS, SAN ANTONIO, FT. SMITH** — Texas Automatic Sprinkler Corp. **DETROIT** — Viking Sprinkler Co. **GRAND RAPIDS** — Viking Sprinkler Co. of Western Mich. **HIGH POINT, N. C.** — Viking Sprinkler Co. **HUNTINGTON, W. VA.** — C. W. Hutchinson, Inc. **DECATUR (Ill.), DENVER, KANSAS CITY (Kan.), OMAHA, SAINT LOUIS, WICHITA** — Walton Viking Co. **LOS ANGELES, SAN FRANCISCO, PHOENIX** — California Viking Sprinkler Co. **HILLSIDE (N. J.), NEW YORK, MANCHESTER (Conn.)** — Viking Sprinkler Co. **PHILADELPHIA, WASHINGTON (D. C.)** — Viking Sprinkler Co. **PORTLAND (Ore.), SEATTLE, VANCOUVER (B. C.)** — Viking Automatic Sprinkler Co. **ST. PAUL, MINNEAPOLIS** — Hudson Viking Sprinkler Co. **TAMPA** — Florida Fire Sprinklers, Inc. **TORONTO (Ont.)** — Viking Automatic Sprinklers, (Canada) Ltd. **HASTINGS, (Mich.)** — The Viking Corporation.

the VIKING corporation

HASTINGS, MICHIGAN

VAN-PACKER
MODEL HT
SMOKESTACK now listed by UNDERWRITERS' LABORATORIES



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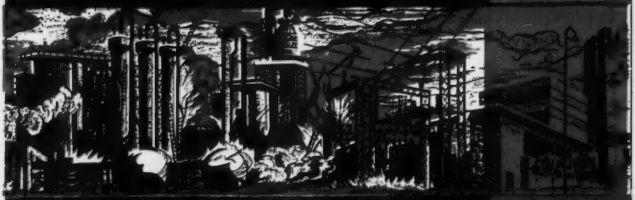

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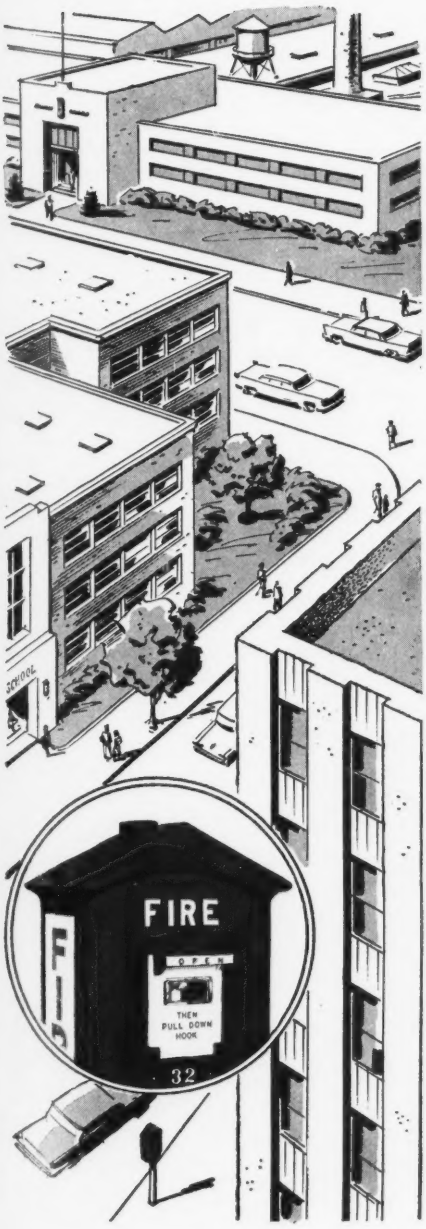

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